PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-184613
(43)Date of publication of application : 03.07.2003

(51)Int.Cl. F02D 41/14
F02D 41/04
F02D 45/00

(21)Application number : 2001-386198
(22)Date of filing : 19.12.2001

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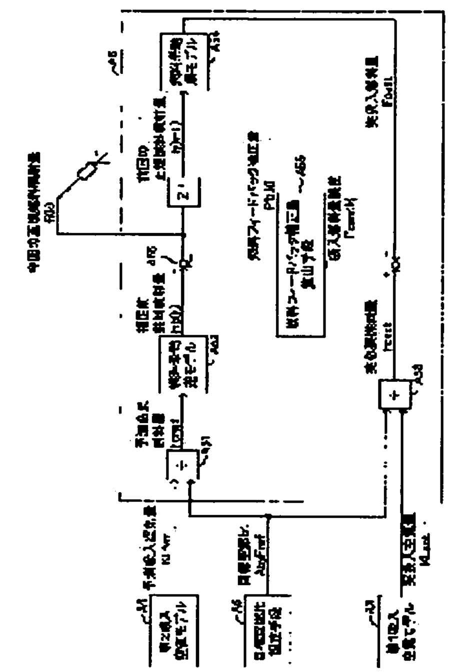
(54) FUEL INJECTION AMOUNT CONTROL METHOD FOR INTERNAL COMBUSTION ENGINE AND ITS DEVICE



(57)Abstract:
PROBLEM TO BE SOLVED: To keep an air/fuel ratio constant by quickly and accurately compensating excess/shortage of supplied fuel amount based on an estimated error of a predicted intake air amount.
SOLUTION: This fuel injection amount control device predicts an intake air amount KLfwd for a current intake stroke in a specified cylinder in accordance with a predicted throttle valve opening, and then finds a predicted required fuel amount Fcfwd in accordance therewith and finds an uncorrected fuel injection amount Fib for supplying fuel of the predicted required fuel amount Fcfwd from a fuel behavior reverse model. On the other hand, the control decice calculates an actual intake air amount KLact in accordance with an actual throttle valve opening in a previous intake stroke, and then finds an actual required fuel amount Fcact in accordance therewith, finds an actual admitted fuel amount Fcest from an actual fuel injection amount Fi (k-1) for the previous intake stroke and a fuel behavior forward model and finds a current regular fuel injection amount Fi (k) after correcting the pre-corrected fuel injection amount Fib depending on a difference Fcerr between the actual required fuel amount Fcact and the actual admitted fuel amount Fcest.

LEGAL STATUS

[Date of request for examination] 26.08.2004

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

CLAIMS

[Claim(s)]
[Claim 1] The amount of operational status of the internal combustion engine at the time of the inlet-valve clausilium in this intake stroke of a specific cylinder is predicted at the event before the time of this inlet-valve clausilium. While computing fuel quantity required in order to predict the inhalation air content in this intake stroke of said specific cylinder according to said predicted amount of operational status and to obtain a predetermined target air-fuel ratio to said predicted inhalation air content as front [amendment] fuel oil consumption It is the fuel-oil-consumption control approach of the internal combustion engine which injects the fuel of an amount according to the fuel oil consumption before said computed amendment to this cylinder at the event before the time of the inlet-valve clausilium in this intake stroke of said specific cylinder. In order to obtain said target air-fuel ratio in the last intake stroke of said cylinder, while calculating the real need fuel quantity which is the fuel quantity actually needed for said cylinder based on the amount of operational status used as known at the event after the inlet-valve clausilium to the last intake stroke of said specific cylinder The real inhalation fuel quantity which is the fuel quantity which said cylinder inhaled actually in the last intake stroke of said cylinder is computed based on the fuel oil consumption actually injected to the last intake stroke of said cylinder at least. It asks for a part for the excess and deficiency of the fuel in the last intake stroke of said cylinder based on said real need fuel quantity and said real inhalation fuel quantity. The fuel-oil-consumption control approach of the internal combustion engine which computes normal fuel oil consumption by amending the fuel oil consumption before said amendment in the amount of amendments according to a part for said called-for excess and deficiency, and injects the fuel of said computed normal fuel oil consumption to this intake stroke of said specific cylinder.
[Claim 2] In the fuel-oil-consumption control unit of the internal combustion engine having a fuel-injection means to perform fuel injection according to directions An amount prediction means of operational status to predict the amount of operational status of said internal combustion engine at the event of the point from this time, An amount acquisition means of operational status to acquire the actual amount of operational status of said internal combustion engine at the event before this time, The prediction inhalation air content which is an inhalation air content at the time of the inlet-valve clausilium in this intake stroke of this cylinder at the 1st predetermined event before the time of the inlet-valve clausilium to this intake stroke of a specific cylinder with said amount prediction means of operational status A prediction inhalation air content calculation means to compute based on the amount of operational status at the event of the point, and the air model which modeled the behavior of the air in said internal combustion engine's inhalation-of-air system from this predicted 1st predetermined event, A fuel-oil-consumption calculation means before amendment to compute the fuel oil consumption before amendment which it is at the event after said 1st predetermined event, and is temporary injection quantity which should be injected to this intake stroke of this cylinder based on said prediction inhalation air content at the 2nd predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder, The real inhalation air content which it is at the event after the time of the inlet-valve clausilium in the last intake stroke of said cylinder, and is a actual inhalation air content at the time of the inlet-valve clausilium in the last intake stroke of this cylinder at the 3rd predetermined event before the time of the inlet-valve clausilium to this intake stroke of this cylinder with said amount acquisition means of operational status A real inhalation air content calculation means to compute based on the acquired actual amount of operational status, and said air model, Are at the event after said 3rd predetermined event, and it sets to the last intake stroke of this cylinder based on said computed real inhalation air content at the 4th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. A real need fuel quantity calculation means to compute the real need fuel

quantity which is the fuel quantity actually needed for this cylinder, It sets to the last intake stroke of this cylinder at the 5th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. A real inhalation fuel quantity calculation means by which this cylinder computes the real inhalation fuel quantity which is the fuel quantity inhaled actually based on the fuel oil consumption actually injected to the last intake stroke of this cylinder at least, Said 4th predetermined event, And an amount calculation means of fuel feedback amendments to be at the event after said 5th predetermined event, and to compute the amount of fuel feedback amendments based on said computed real need fuel quantity and said computed real inhalation fuel quantity at the 6th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder Said 2nd predetermined event, And by being at the event after said 6th predetermined event, and amending the fuel oil consumption before said computed amendment in said computed amount of fuel feedback amendments at the 7th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder A normal fuel-oil-consumption calculation means to compute the fuel oil consumption of the normal injected from said fuel-injection means to this intake stroke of this cylinder, A fuel-injection directions means to be at the event after said 7th predetermined event, and to give directions so that the fuel of the fuel oil consumption of said computed normal may be injected to said fuel-injection means at the 8th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder, The fuel-oil-consumption control unit of preparation **********.

[Claim 3] The fuel oil consumption before amendment to the intake stroke of the arbitration of said cylinder which is the fuel-oil-consumption control unit of an internal combustion engine according to claim 2, and is computed by said fuel-oil-consumption calculation means before amendment, The prediction fuel coating weight which is after the intake stroke 1 time before the intake stroke of this arbitration of this cylinder, and is the predicted fuel coating weight in front of the intake stroke of this arbitration, A prediction fuel coating weight calculation means to compute the prediction fuel coating weight in front of the intake stroke next to the intake stroke of this arbitration by being after the intake stroke of this arbitration of this cylinder based on the fuel behavior model showing the fuel adhesion behavior to said internal combustion engine's inhalation-of-air system, The real fuel coating weight which is after the intake stroke 1 time before the intake stroke of the fuel oil consumption actually injected to the intake stroke of the arbitration of said cylinder, and this arbitration of this cylinder, and is the actual fuel coating weight in front of the intake stroke of this arbitration, While having a real fuel coating weight calculation means to compute the real fuel coating weight in front of the intake stroke next to the intake stroke of this arbitration by being after the intake stroke of this arbitration of this cylinder, based on said fuel behavior model Said fuel-oil-consumption calculation means before amendment computes the prediction need fuel quantity which is the fuel quantity needed for this cylinder by this intake stroke of this cylinder based on the prediction inhalation air content at the time of the inlet-valve clausilium to this intake stroke of said cylinder computed by said prediction inhalation air content calculation means. It is based on the reverse model of said fuel behavior model. It sets to this intake stroke of this cylinder among the fuels of the fuel oil consumption before amendment which should be injected to this intake stroke of said cylinder. Are after the intake stroke of the last time of this cylinder computed by the fuel quantity inhaled by this cylinder and said prediction fuel coating weight calculation means, and it sets to this intake stroke of this cylinder among the fuels of the prediction fuel coating weight in front of this intake stroke. It is constituted so that the sum with the fuel quantity inhaled by this cylinder may become equal to said computed prediction need fuel quantity and the fuel oil consumption before the said amendment may be computed. Said real inhalation fuel quantity calculation means It is based on the order model of said fuel behavior model. It sets to the last intake stroke of this cylinder among the fuels of the fuel oil consumption actually injected to the last intake stroke of said cylinder. From the fuel quantity which is after the intake stroke of the second from last time of this cylinder computed by this cylinder with the fuel quantity inhaled actually and said real fuel coating weight calculation means, and was actually inhaled by this cylinder in the last intake stroke of this cylinder among the fuels of the real fuel coating weight in front of the last intake stroke The fuel-oil-consumption control unit which is constituted and becomes so that said real inhalation fuel quantity which this cylinder inhaled actually in the last intake stroke of this cylinder may be computed.

[Claim 4] In the fuel-oil-consumption control unit of the internal combustion engine having a fuel-injection means to perform fuel injection according to directions An amount prediction means of operational status to predict the amount of operational status of said internal combustion engine at the event of the point from this time, An amount acquisition means of operational status to acquire the actual amount of operational status of said internal combustion engine at the event before this time, The prediction inhalation air content which

is an inhalation air content at the time of the inlet-valve clausilium in this intake stroke of this cylinder at the 1st predetermined event before the time of the inlet-valve clausilium to this intake stroke of a specific cylinder with said amount prediction means of operational status A prediction inhalation air content calculation means to compute based on the amount of operational status at the event of the point, and the air model which modeled the behavior of the air in said internal combustion engine's inhalation-of-air system from this predicted 1st predetermined event, While computing the prediction need fuel quantity which it is at the event after said 1st predetermined event, and is the fuel quantity needed for this cylinder by this intake stroke of said cylinder based on said prediction inhalation air content at the 2nd predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder Based on said prediction inhalation air content, determine the deposit efficiency and residual percentage which are used with the reverse model showing the fuel adhesion behavior to said internal combustion engine's inhalation-of-air system of a fuel behavior model, and by using this reverse model which used the said-determined deposit efficiency and residual percentage It sets to this intake stroke of this cylinder among the fuels of the fuel oil consumption before amendment which is temporary injection quantity which should be injected to this intake stroke of this cylinder. The sum with the fuel quantity inhaled by this cylinder in this intake stroke of this cylinder among the fuels of the prediction fuel coating weight which is after the intake stroke of the last time of the fuel quantity inhaled by this cylinder and this cylinder, and is the predicted fuel coating weight in front of this intake stroke A fuel-oil-consumption calculation means before amendment to compute the fuel oil consumption before the said amendment so that it may become equal to said computed prediction need fuel quantity, At the 3rd predetermined event before said 2nd predetermined event, the deposit efficiency and residual percentage which are used with said fuel behavior model are determined based on the prediction inhalation air content over the last intake stroke of said cylinder. This fuel behavior model which used the said-determined deposit efficiency and residual percentage, and the prediction [are after the intake stroke of the second from last time of this cylinder, and] fuel coating weight before the last intake stroke, A prediction fuel coating weight calculation means to compute said prediction fuel coating weight in front of this intake stroke by being after the intake stroke of the last time of this cylinder based on the fuel oil consumption before amendment to the last intake stroke of this cylinder, Are at the event after the time of the inlet-valve clausilium to the last intake stroke of said cylinder, and at the 4th predetermined event before the time of the inlet-valve clausilium to this intake stroke of this cylinder A real inhalation air content calculation means to compute the real inhalation air content which is a actual inhalation air content at the time of the inlet-valve clausilium to the last intake stroke of this cylinder based on the actual amount of operational status acquired by said operational status acquisition means, and said air model, Are at the event after said 4th predetermined event, and at the 5th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder This fuel behavior model which determined the deposit efficiency and residual percentage which are used with said fuel behavior model based on the real inhalation air content at the time of the inlet-valve clausilium to the last intake stroke of this cylinder, and used the said-determined deposit efficiency and residual percentage, It is based on the fuel oil consumption actually injected to the last intake stroke of this cylinder, and the real fuel coating weight which is after the intake stroke of the second from last time of this cylinder, and is the actual fuel coating weight in front of the last intake stroke. A real fuel coating weight calculation means to compute the real fuel coating weight in front of this intake stroke by being after the intake stroke of the last time of this cylinder, Are at the event after said said 3rd predetermined and 5th predetermined event, and at the 6th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The prediction [are after the intake stroke of the last time of this cylinder computed by said prediction fuel coating weight calculation means, and] fuel coating weight before this intake stroke, An amount calculation means of fuel feedback amendments to be after the intake stroke of the last time of this cylinder computed by said real fuel coating weight calculation means, and to compute the amount of fuel feedback amendments based on the real fuel coating weight in front of this intake stroke, Are at the event after said said 2nd predetermined and 6th predetermined event, and at the 7th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder A normal fuel-oil-consumption calculation means to compute the fuel oil consumption of the normal injected from said fuel-injection means to this intake stroke of said cylinder by amending the fuel oil consumption before amendment which should be injected to this intake stroke of said this computed cylinder in said computed amount of fuel feedback amendments, A fuel-injection directions means to be at the event after said 7th predetermined event, and to give directions so that the fuel of the fuel oil consumption of said computed normal may be injected to said fuel-injection means at the 8th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder, The

fuel-oil-consumption control unit of preparation **********.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the fuel-oil-consumption control approach which an internal combustion engine's fuel-oil-consumption control unit is started, especially can maintain an air-fuel ratio to abbreviation regularity at the time of transient operation, and a fuel-oil-consumption control unit.
[0002]
[Description of the Prior Art] A cylinder [need / the fuel in an electronically-controlled-gasoline-injection-type internal combustion engine, an intake-stroke direct front stirrup is in an intake stroke, and according to fuel injection / to be supplied] (It is hereafter called a "fuel-injection cylinder".) It is necessary to calculate the inhalation air content in this intake stroke, and to inject the fuel of an amount according to this calculated inhalation air content even before this intake-stroke initiation at the latest depending on the case by the time of the inlet-valve clausilium to this intake stroke (at the event of the condition of an inlet valve changing from an open condition to a closed state). For this reason, for example, an internal combustion engine's control unit indicated by JP,10-169469,A Whenever [throttle valve-opening / which is one of the amounts of operational status of this internal combustion engine] is beforehand predicted till the inlet-valve clausilium of a fuel-injection cylinder. It is based on whenever [throttle valve-opening / which was said-predicted at least], and the air model which modeled the behavior of the air an internal combustion engine's inhalation-of-air system, and the inhalation air content at the time of the inlet-valve clausilium of this fuel-injection cylinder is predicted at the event before the time of this inlet-valve clausilium. The fuel of fuel oil consumption according to the predicted inhalation air content is injected to this cylinder.
[0003]
[Problem(s) to be Solved by the Invention] However, the above-mentioned conventional control unit has the problem that fuel oil consumption serves as a suitable value and a different value, and an air-fuel ratio is confused for the reason nil why whenever [throttle valve-opening / which was predicted], and whenever [actual throttle valve-opening] are different for example, etc. since it does not have a means to compensate this presumed error, if a difference (presumed error) arises between the predicted inhalation air content and a actual inhalation air content. Therefore, the object of this invention compensates the presumed error of an inhalation air content promptly, and is to offer fuel-oil-consumption control approach and fuel-oil-consumption control unit of the internal combustion engine which can stabilize promptly the air-fuel ratio at the time of transient operation of whenever [throttle valve-opening] changing suddenly especially.
[0004]
[Summary of the Invention] The fuel-oil-consumption control approach of this invention predicts the amount of operational status of the internal combustion engine at the time of the inlet-valve clausilium in this intake stroke of a specific cylinder at the event before the time of this inlet-valve clausilium. While computing fuel quantity required in order to predict the inhalation air content in this intake stroke of said specific cylinder according to said predicted amount of operational status and to obtain a predetermined target air-fuel ratio to said predicted inhalation air content as front [amendment] fuel oil consumption It is the fuel-oil-consumption control approach of the internal combustion engine which injects the fuel of an amount according to the fuel oil consumption before said computed amendment to this cylinder at the event before the time of the inlet-valve clausilium in this intake stroke of said specific cylinder. In order to obtain said target air-fuel ratio in the last intake stroke of said cylinder, while calculating the real need fuel quantity which is the fuel quantity actually needed for said cylinder based on the amount of operational status used as known at the event after the inlet-valve clausilium to the last intake stroke of said specific cylinder The real inhalation fuel quantity which is the fuel quantity which said cylinder inhaled actually in the last intake

stroke of said cylinder is computed based on the fuel oil consumption actually injected to the last intake stroke of said cylinder at least. It asks for a part for the excess and deficiency of the fuel in the last intake stroke of said cylinder based on said real need fuel quantity and said real inhalation fuel quantity. It is the approach of computing normal fuel oil consumption by amending the fuel oil consumption before said amendment in the amount of amendments according to a part for said called-for excess and deficiency, and injecting the fuel of said computed normal fuel oil consumption to this intake stroke of said specific cylinder.

[0005] This fuel-oil-consumption control approach computes the fuel oil consumption before amendment which is equivalent to the basic injection quantity based on the inhalation air content which predicted and predicted the inhalation air content at the time of the inlet-valve clausilium in this intake stroke of a specific cylinder (it is the same one cylinder of an internal combustion engine's arbitration of two or more cylinders, and the following.) based on the predicted amount of operational status (for example, whenever [throttle valve-opening]) at the event before the time of this inlet-valve clausilium. Therefore, the fuel oil consumption before amendment is influenced of the prediction error (presumed error) of a prediction inhalation air content.

[0006] In after the inlet-valve clausilium of the last intake stroke of a specific cylinder on the other hand Since the amount of operational status at the inlet-valve clausilium event in the last intake stroke of this specific cylinder is known The actual inhalation air content of the last intake stroke of this cylinder can be calculated from the amount of operational status which is the known. Therefore, since the air-fuel ratio of the gaseous mixture in this specific cylinder turns into a target air-fuel ratio by the last intake stroke of this specific cylinder, accuracy can be asked for the actually needed fuel quantity (real need fuel quantity). On the other hand, since the fuel oil consumption actually injected to the intake stroke of ****** after the inlet-valve clausilium of the last intake stroke is known, accuracy can be asked for the actual inhalation fuel quantity (real inhalation fuel quantity) of the last intake stroke of this cylinder based on the fuel oil consumption which is the known at least.

[0007] This fuel-oil-consumption control approach calculates real need fuel quantity and real inhalation fuel quantity in this way, computes the excess and deficiency of the fuel in the last intake stroke based on these real need fuel quantity and real inhalation fuel quantity (difference), and amends the fuel oil consumption before said amendment in quest of the amount of amendments for compensating this ********. every [therefore,] cylinder -- and since a part for the excess and deficiency of the fuel in the last intake stroke is compensated with this intake stroke at least for every intake stroke, quickness and precision are good and an air-fuel ratio can be maintained uniformly.

[0008] More moreover, the fuel-oil-consumption control unit (the following, the "1st fuel-oil-consumption control unit", and nominal ****.) of the internal combustion engine of this invention as a concrete mode It is the fuel-oil-consumption control unit of the internal combustion engine having a fuel-injection means to perform fuel injection according to directions. The amount prediction means of operational status, the amount acquisition means of operational status, a prediction inhalation air content calculation means, It has a front [amendment] fuel-oil-consumption calculation means, a real inhalation air content calculation means, a real need fuel quantity calculation means, a real inhalation fuel quantity calculation means, the amount calculation means of fuel feedback amendments, a normal fuel-oil-consumption calculation means, and a fuel-injection directions means. Hereafter, an operation of each means is explained.

[0009] The amount prediction means of operational status predicts the amount of operational status of said internal combustion engine at the event of the point from this time. The amount acquisition means of operational status acquires the actual amount of operational status of said internal combustion engine at the event before this time. Whenever [throttle valve-opening] is mentioned as an example of representation of the amount of operational status.

[0010] A prediction inhalation air content calculation means at the 1st predetermined event before the time of the inlet-valve clausilium to this intake stroke of a specific cylinder (a certain cylinder) Based on the amount of operational status at the event of the point, and the air model which modeled the behavior of the air in said internal combustion engine's inhalation-of-air system, it computes from this 1st predetermined event predicted by said amount prediction means of operational status in the prediction inhalation air content which is an inhalation air content at the time of the inlet-valve clausilium in this intake stroke of this cylinder. That is, a prediction inhalation air content calculation means predicts the inhalation air content of this cylinder at the time of this inlet-valve clausilium at the 1st predetermined event before the event (at the time of inlet-valve clausilium) of next the inlet valve of the cylinder used as the close wax (or close is already in an intake stroke) making it an intake stroke from a valve-opening condition henceforth to a

clausilium condition in the intake stroke.
[0011] The fuel-oil-consumption calculation means before amendment computes the fuel oil consumption before amendment which it is at the event after said 1st predetermined event, and is temporary injection quantity which should be injected to this intake stroke of this cylinder based on said prediction inhalation air content at the 2nd predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. For example, the fuel-oil-consumption calculation means before amendment can compute the fuel oil consumption before amendment by **(ing) said prediction inhalation air content with the target air-fuel ratio separately defined according to an internal combustion engine's operational status (or it is fixed). In this case, it is suitable to calculate the fuel oil consumption before amendment in consideration of fuel coating weight so that it may mention later.
[0012] Are a real inhalation air content calculation means at the event after the time of the inlet-valve clausilium in the last intake stroke of said cylinder, and at the 3rd predetermined event before the time of the inlet-valve clausilium to this intake stroke of this cylinder The real inhalation air content which is a actual inhalation air content at the time of the inlet-valve clausilium in the last intake stroke of this cylinder is computed based on the actual amount of operational status acquired by said amount acquisition means of operational status, and said air model. Since it is at this 3rd predetermined event at the event after the time of the inlet-valve clausilium in the last intake stroke of said cylinder, the amount of operational status for calculating the actual inhalation air content at the time of the inlet-valve clausilium in the last intake stroke of this cylinder is known, and is acquired by said **** quantity of state acquisition means. Therefore, accuracy is asked for a real inhalation air content based on the amount of operational status and air model of this known.
[0013] A real need fuel quantity calculation means computes the real need fuel quantity which it is at the event after said 3rd predetermined event, and is the fuel quantity actually needed for this cylinder in the last intake stroke of this cylinder based on said computed real inhalation air content at the 4th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. for example, a real need fuel calculation means -- said fuel-oil-consumption calculation means before amendment -- the same -- said target air-fuel ratio -- said real inhalation air content -- **** -- real need fuel quantity is computable with things.
[0014] A real inhalation fuel quantity calculation means is computed based on the fuel oil consumption actually injected to the last intake stroke of this cylinder at least in the real inhalation fuel quantity which is the fuel quantity which this cylinder inhaled actually in the last intake stroke of this cylinder at the 5th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. In this case, it is suitable to be also able to adopt the fuel oil consumption (normal fuel oil consumption) of normal as fuel oil consumption injected actually, and to calculate real inhalation fuel quantity in consideration of still more nearly actual fuel coating weight (real fuel coating weight) so that it may mention later.
[0015] It is the amount calculation means of fuel feedback amendments at the event after said said 4th predetermined and 5th predetermined event, and it computes the amount of fuel feedback amendments based on said computed real need fuel quantity and said computed real inhalation fuel quantity at the 6th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder.
[0016] For example, the difference of said computed real need fuel quantity and said computed real inhalation fuel quantity is using the difference of this fruit need fuel quantity and this fruit inhalation fuel quantity, and controllers, such as proportional-plus-integral control which makes this difference an input value, since a part for the excess and deficiency of the fuel in the last intake stroke is expressed, and the amount of fuel feedback amendments which compensates a part for the excess and deficiency of this fuel is computed.
[0017] Are a normal fuel-oil-consumption calculation means at the event after said said 2nd predetermined and 6th predetermined event, and at the 7th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The fuel oil consumption of the normal injected from said fuel-injection means to this intake stroke of this cylinder is computed by amending the fuel oil consumption before said computed amendment in said computed amount of fuel feedback amendments.
[0018] And it is a fuel-injection directions means at the event after said 7th predetermined event, directions are given so that the fuel of the fuel oil consumption of said computed normal may be injected to said fuel-injection means at the 8th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder, and thereby, the fuel of the fuel oil consumption of normal is injected from a fuel-injection means.

[0019] The 1st fuel-oil-consumption control unit repeats and performs the above processing for every cylinder for every intake stroke of each cylinder, is that (it compensates) which reflects promptly a part for the excess and deficiency of the fuel in the last intake stroke of a specific cylinder in the fuel oil consumption after the next time of the cylinder of this specification, and can maintain it to the value stabilized in the air-fuel ratio.
[0020] In this case, while the above-mentioned 1st fuel-oil-consumption control unit is equipped with a prediction fuel coating weight calculation means to compute prediction fuel coating weight and said fuel-oil-consumption calculation means before amendment computes prediction need fuel quantity It is constituted so that the fuel oil consumption before said amendment may be computed using the reverse model of a fuel behavior model, taking into consideration said computed prediction fuel coating weight so that this prediction need fuel quantity may be supplied. Furthermore, it is suitable to be constituted so that said real inhalation fuel quantity may be computed using the order model of a fuel behavior model, having a real fuel coating weight calculation means to compute real fuel coating weight, and taking into consideration this real fuel coating weight.
[0021] According to this, since fuel oil consumption is determined and it goes while the fuel coating weight which changes according to an engine's operational status is taken into consideration, the fuel oil consumption of suitable normal is computed to each cylinder, consequently an air-fuel ratio can be stabilized further.
[0022] When it states more concretely, a prediction fuel coating weight calculation means The fuel oil consumption before amendment to the intake stroke of the arbitration of said cylinder computed by said fuel-oil-consumption calculation means before amendment, The prediction fuel coating weight which is after the intake stroke 1 time before the intake stroke of this arbitration of this cylinder, and is the predicted fuel coating weight in front of the intake stroke of this arbitration, Based on the fuel behavior model showing the fuel adhesion behavior to said internal combustion engine's inhalation-of-air system, the prediction fuel coating weight in front of the intake stroke next to the intake stroke of this arbitration is computed by being after the intake stroke of this arbitration of this cylinder.
[0023] Namely, a prediction fuel coating weight calculation means is set when it is assumed that the fuel of the fuel oil consumption before amendment was injected to a certain intake stroke. New prediction fuel coating weight (namely, a certain said intake-stroke back) is computed from the amount of the fuel which remains in the inhalation-of-air system of the amount of the fuel adhering to the inhalation-of-air system of the fuels of the fuel oil consumption before the said amendment, and the prediction fuel coating weight predicted to have adhered to the inhalation-of-air system in front of the intake stroke.
[0024] The fuel oil consumption by which the real fuel coating weight calculation means was actually injected to the intake stroke of the arbitration of said cylinder, The real fuel coating weight which is after the intake stroke 1 time before the intake stroke of this arbitration of this cylinder, and is the actual fuel coating weight in front of the intake stroke of this arbitration, Based on said fuel behavior model, the real fuel coating weight in front of the intake stroke 1 time after the intake stroke of this arbitration is computed by being after the intake stroke of this arbitration of this cylinder.
[0025] That is, a real fuel coating weight calculation means computes new real fuel coating weight (a certain said intake-stroke back) from the amount of the fuel which remains in the inhalation-of-air system of the amount of the fuel adhering to the inhalation-of-air system of the fuels of the fuel oil consumption actually injected to a certain intake stroke, and the real fuel coating weight which had adhered to the inhalation-of-air system in front of the intake stroke.
[0026] And said fuel-oil-consumption calculation means before amendment computes the prediction need fuel quantity which is the fuel quantity needed for this cylinder by this intake stroke of this cylinder based on the prediction inhalation air content at the time of the inlet-valve clausilium to this intake stroke of said cylinder computed by said prediction inhalation air content calculation means. It is based on the reverse model of said fuel behavior model. It sets to this intake stroke of this cylinder among the fuels of the fuel oil consumption before amendment which should be injected to this intake stroke of said cylinder. Are after the intake stroke of the last time of this cylinder computed by the fuel quantity inhaled by this cylinder and said prediction fuel coating weight calculation means, and it sets to this intake stroke of this cylinder among the fuels of the prediction fuel coating weight in front of this intake stroke. It is constituted so that the sum with the fuel quantity inhaled by this cylinder may become equal to said computed prediction need fuel quantity and the fuel oil consumption before the said amendment may be computed.
[0027] namely, said fuel-oil-consumption calculation means before amendment from the prediction inhalation air content at the time of the inlet-valve clausilium to this predicted intake stroke In order to

compute the fuel quantity (prediction need fuel quantity) needed by the intake stroke of this this time and for this prediction need fuel quantity to be inhaled by the cylinder A part to be inhaled [the fuel of the fuel oil consumption of which must be injected, and] by the cylinder, without adhering to an inhalation system among the fuels of this fuel oil consumption, And let fuel oil consumption which computed in consideration of a part to this cylinder of the fuels of the predicted prediction fuel coating weight in front of this intake stroke to be inhaled, and was computed by making it such be the fuel oil consumption before amendment.
[0028] Moreover, said real inhalation fuel quantity calculation means is based on the order model of said fuel behavior model. The fuel quantity actually inhaled by this cylinder in the last intake stroke of this cylinder among the fuels of the fuel oil consumption actually injected to the last intake stroke of said cylinder, and from the fuel quantity which is after the intake stroke of the second from last time of this cylinder computed by said real fuel coating weight calculation means, and was actually inhaled by this cylinder in the last intake stroke of this cylinder among the fuels of the real fuel coating weight in front of the last intake stroke It is constituted so that said real inhalation fuel quantity which this cylinder inhaled actually in the last intake stroke of this cylinder may be computed.
[0029] That is, said real inhalation fuel quantity calculation means computes a part to be inhaled by the cylinder among the fuels of actual fuel oil consumption to the last intake stroke, and the sum to be inhaled by the cylinder among the fuels of the actual fuel coating weight in front of the last intake stroke as inhalation fuel quantity actually inhaled in the last intake stroke.
[0030] If it does in this way, since the fuel oil consumption before amendment will be computed by fuel coating weight being taken into consideration, when there is no prediction error of an inhalation air content, the fuel of very close fuel quantity will be supplied to real need fuel quantity by the fuel supply of the fuel oil consumption before the said amendment, and the air-fuel ratio for every intake stroke is stabilized by it. Furthermore, since real inhalation fuel quantity is calculated with a sufficient precision, accuracy is asked for a part for the excess and deficiency of the inhaled fuel and a part for this excess and deficiency is reflected in the amount of feedback amendments by fuel coating weight being taken into consideration, an air-fuel ratio can be further stabilized as a result.
[0031] The fuel-oil-consumption control unit (the following, the "2nd fuel-oil-consumption control unit", and nominal ****.) of the internal combustion engine concerning other modes by this invention It is based on the known fuel oil consumption (real fuel oil consumption) actually injected in the last intake stroke of a certain cylinder (specific cylinder), the actual fuel coating weight in front of the intake stroke of the last time of this cylinder (real fuel coating weight), and a fuel behavior model, and the real fuel coating weight in front of this intake stroke is calculated. At this time, the deposit efficiency and residual percentage of a fuel behavior model are determined based on the actual inhalation air content at the time of the inlet-valve clausilium to the intake stroke of this **** called for based on the amount of operational status and air model which became known behind at the time of the inlet-valve clausilium to the last intake stroke (real inhalation air content). Thereby, since real fuel coating weight is computed based on the deposit efficiency of a fuel behavior model and residual percentage which were called for based on the actual inhalation air content, and actual fuel oil consumption, it turns into an amount which expresses actual fuel coating weight with a sufficient precision.
[0032] On the other hand, the 2nd fuel-oil-consumption control unit calculates the fuel oil consumption before amendment, taking into consideration the prediction fuel coating weight in front of the intake stroke of this this time so that the prediction need fuel quantity according to the predicted inhalation air content may be obtained while predicting the inhalation air content at the time of this inlet-valve clausilium at the event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. At this time, the 2nd fuel-oil-consumption control device determines the deposit efficiency and residual percentage which are used with a fuel behavior model based on the prediction inhalation air content over the last intake stroke of this cylinder (it became the foundation which computes the fuel oil consumption before amendment). It is after this fuel behavior model which used the said-determined deposit efficiency and residual percentage, and the intake stroke of the second from last time of this cylinder. The prediction fuel coating weight in front of the intake stroke of the last time of this cylinder, It is based on the fuel oil consumption before amendment to the last intake stroke, and the prediction fuel coating weight in front of the intake stroke of this time of said cylinder is predicted. Consequently, prediction fuel coating weight serves as a value in which the prediction inhalation air content over the last intake stroke was reflected.
[0033] And said real [control unit / 2nd fuel-oil-consumption] fuel coating weight in front of this intake stroke, The value according to a part for the excess and deficiency of a fuel [in / based on said prediction fuel coating weight in front of the intake stroke of this this time / the last intake stroke] (Namely, the value

reflecting the error over the real inhalation air content of a prediction inhalation air content) is calculated, the amount of fuel feedback amendments to this intake stroke is computed according to the value, and the amount of said fuel feedback amendments amends the fuel oil consumption before amendment. An air-fuel ratio can be stabilized by the above.

[0034] If it states more concretely, it is an internal combustion engine's fuel-oil-consumption control unit which it had in the fuel-injection means which performs in fuel injection according to directions, and the 2nd fuel-oil-consumption control unit will have the amount prediction means of operational status, the amount acquisition means of operational status, a prediction inhalation air content calculation means, a front [amendment] fuel-oil-consumption calculation means, a prediction fuel coating-weight calculation means, a real inhalation air content calculation means, a real fuel coating-weight calculation means, the amount calculation means of fuel feedback amendments, a normal fuel-oil-consumption calculation means, and a fuel-injection directions means. Hereafter, an operation of each means is explained.

[0035] The amount prediction means of operational status predicts the amount of operational status of said internal combustion engine at the event of the point from this time. The amount acquisition means of operational status acquires the actual amount of operational status of said internal combustion engine at the event before this time. Whenever [throttle valve-opening] is mentioned as an example of representation of the amount of operational status.

[0036] A prediction inhalation air content calculation means The prediction inhalation air content which is an inhalation air content at the time of the inlet-valve clausilium in this intake stroke of this cylinder at the 1st predetermined event before the time of the inlet-valve clausilium to this intake stroke of a specific cylinder with said amount prediction means of operational status Based on the amount of operational status at the event of the point, and the air model which modeled the behavior of the air in said internal combustion engine's inhalation-of-air system, it computes from this predicted 1st predetermined event. That is, the prediction inhalation air content calculation means is used as the close wax next like it of the 1st fuel-oil-consumption control unit at the intake stroke (). or close is already in an intake stroke -- the inhalation air content of this cylinder at the time of this inlet-valve clausilium is predicted at the 1st predetermined event before the event (at the time of inlet-valve clausilium) of the inlet valve of a cylinder carrying out from a valve-opening condition henceforth to a clausilium condition in the intake stroke.

[0037] The fuel-oil-consumption calculation means before amendment computes the prediction need fuel quantity which it is at the event after said 1st predetermined event, and is the fuel quantity needed for this cylinder by this intake stroke of said cylinder based on said prediction inhalation air content at the 2nd predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. For example, the fuel-oil-consumption calculation means before amendment can compute prediction need fuel quantity by **(ing) said prediction inhalation air content with the target air-fuel ratio separately defined according to an internal combustion engine's operational status (or it is fixed).

[0038] Furthermore, the fuel-oil-consumption calculation means before amendment determines the deposit efficiency and residual percentage which are used with the reverse model showing the fuel adhesion behavior to said internal combustion engine's inhalation-of-air system of a fuel behavior model based on said prediction inhalation air content. By using this reverse model which used the said-determined deposit efficiency and residual percentage It sets to this intake stroke of this cylinder among the fuels of the fuel oil consumption before amendment which is temporary injection quantity which should be injected to this intake stroke of this cylinder. The sum with the fuel quantity inhaled by this cylinder in this intake stroke of this cylinder among the fuels of the prediction fuel coating weight which is after the intake stroke of the last time of the fuel quantity inhaled by this cylinder and this cylinder, and is the predicted fuel coating weight in front of this intake stroke The fuel oil consumption before the said amendment is computed so that it may become equal to said computed prediction need fuel quantity.

[0039] A prediction fuel coating weight calculation means at the 3rd predetermined event before said 2nd predetermined event A prediction inhalation air content [as opposed to the last intake stroke of said cylinder for the deposit efficiency and residual percentage which are used with said fuel behavior model] It determines based on (namely, the inhalation air content which said prediction inhalation air content calculation means computed as an inhalation air content at the time of the inlet-valve clausilium to the intake stroke of this **** at the event before the time of the inlet-valve clausilium to the last intake stroke). This fuel behavior model which used the said-determined deposit efficiency and residual percentage, and the prediction [are after the intake stroke of the second from last time of this cylinder, and] fuel coating weight before the last intake stroke, Based on the fuel oil consumption before amendment to the last intake stroke of this cylinder, said prediction fuel coating weight in front of this intake stroke is computed by being after

the intake stroke of the last time of this cylinder.
[0040] Are a real inhalation air content calculation means at the event after the time of the inlet-valve clausilium to the last intake stroke of said cylinder, and at the 4th predetermined event before the time of the inlet-valve clausilium to this intake stroke of this cylinder The real inhalation air content which is a actual inhalation air content at the time of the inlet-valve clausilium to the last intake stroke of this cylinder is computed based on the actual amount of operational status acquired by said operational status acquisition means, and said air model. Since it is at this 4th predetermined event at the event after the time of the inlet-valve clausilium in the last intake stroke of said cylinder, the amount of operational status for calculating the actual inhalation air content at the time of the inlet-valve clausilium in the last intake stroke of this cylinder is known, and is acquired by said **** quantity of state acquisition means. Therefore, accuracy is asked for a real inhalation air content with the known amount of operational status and a known air model.
[0041] Are a real fuel coating weight calculation means at the event after said 4th predetermined event, and at the 5th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder This fuel behavior model which determined the deposit efficiency and residual percentage which are used with said fuel behavior model based on the real inhalation air content at the time of the inlet-valve clausilium to the last intake stroke of this cylinder, and used the said-determined deposit efficiency and residual percentage, It is based on the fuel oil consumption actually injected to the last intake stroke of this cylinder, and the real fuel coating weight which is after the intake stroke of the second from last time of this cylinder, and is the actual fuel coating weight in front of the last intake stroke. The real fuel coating weight in front of this intake stroke is computed by being after the intake stroke of the last time of this cylinder. Thus, since real fuel coating weight is computed based on a real inhalation air content and real fuel oil consumption, this fruit fuel coating weight turns into true fuel coating weight and a very close amount.
[0042] Are the amount calculation means of fuel feedback amendments at the event after said said 3rd predetermined and 5th predetermined event, and at the 6th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The prediction [are after the intake stroke of the last time of this cylinder computed by said prediction fuel coating weight calculation means, and] fuel coating weight before this intake stroke, It is after the intake stroke of the last time of this cylinder computed by said real fuel coating weight calculation means, and the amount of fuel feedback amendments is computed based on the real fuel coating weight in front of this intake stroke.
[0043] That is, said computed prediction fuel coating weight is a value reflecting a prediction inhalation air content, and since said computed real fuel coating weight is a value reflecting a real inhalation air content, the difference of said prediction fuel coating weight and said real fuel coating weight expresses a part for the presumed error of the inhalation air content in the last intake stroke, therefore the excess and deficiency of a fuel. Therefore, if the amount of fuel feedback amendments is computed by controllers, such as proportional-plus-integral control, so that said prediction fuel coating weight and said real fuel oil consumption may be in agreement for example, the amount of said fuel feedback amendments will serve as a value which compensates a part for the excess and deficiency of a fuel.
[0044] Are a normal fuel-oil-consumption calculation means at the event after said said 2nd predetermined and 6th predetermined event, and at the 7th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The fuel oil consumption of the normal injected from said fuel-injection means to this intake stroke of said cylinder is computed by amending the fuel oil consumption before amendment which should be injected to this intake stroke of said this computed cylinder in said computed amount of fuel feedback amendments.
[0045] And it is a fuel-injection directions means at the event after said 7th predetermined event, directions are given so that the fuel of the fuel oil consumption of said computed normal may be injected to said fuel-injection means at the 8th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder, and thereby, the fuel of the fuel oil consumption of normal is injected from a fuel-injection means.
[0046] Since the 2nd fuel-oil-consumption control unit repeats and performs the above processing for every intake stroke of each cylinder and compensates fuel oil consumption, such as each mind on and after next time, for it reflecting a part for the excess and deficiency of the fuel in the last intake stroke for every cylinder, an air-fuel ratio is maintainable to the stable value.
[0047] In addition, also in any of the above-mentioned 1st and 2nd fuel-oil-consumption control unit, it is necessary to be only the time amount which fuel injection takes, the time amount taken to inhale the injected fuel in a cylinder, and the time amount of the sum of ** actually at the event before the time of inlet-valve clausilium at the predetermined event of the above 8th. However, the case of a cylinder-injection-of-fuel-

type internal combustion engine, when the flow rate of the injector as a fuel-injection means is very large, it should just be at the predetermined event of ** an 8th at the predetermined event before the time of inlet-valve clausilium. Moreover, the 8th predetermined time may be after fuel-injection initiation.

[0048]

[Embodiment of the Invention] Hereafter, it explains, referring to a drawing about each operation gestalt of the control unit of the internal combustion engine by this invention. Drawing 1 shows the outline configuration of the system which applied the fuel-oil-consumption control unit (the 1st fuel-oil-consumption control unit) concerning the 1st operation gestalt of this invention to the jump-spark-ignition type Taki cylinder (4-cylinder) internal combustion engine 10.

[0049] This internal combustion engine 10 contains the induction system 40 for supplying a gasoline mixture to the cylinder block section 20 containing a cylinder block, a cylinder block ROWA case, an oil pan mechanism, etc., the cylinder head section 30 fixed on the cylinder block section 20, and the cylinder block section 20, and the exhaust system 50 for emitting the exhaust gas from the cylinder block section 20 outside.

[0050] The cylinder block section 20 contains the cylinder 21, the piston 22, the connecting rod 23, and the crankshaft 24. The inside of a cylinder 21 is reciprocated, reciprocation of a piston 22 is transmitted to a crankshaft 24 through a connecting rod 23, and, thereby, this crankshaft 24 rotates a piston 22. The head of a cylinder 21 and a piston 22 forms the combustion chamber 25 with the cylinder head section 30.

[0051] The cylinder head section 30 While the intake cam shaft which drives the inlet valve 32 which opens and closes the inlet port 31 which was open for free passage to the combustion chamber 25, and an inlet port 31, and an inlet valve 32 is included Actuator 33a of adjustable inhalation-of-air timing equipment 33 and adjustable inhalation-of-air timing equipment 33 which changes the phase angle of this intake cam shaft continuously, The exhaust port 34 and exhaust port 34 which were open for free passage to the combustion chamber 25 The exhaust valve 35 and exhaust valve 35 which are opened and closed It has the ignitor 38 containing the ignition coil which generates the high tension given to the exhaust cam shaft 36 to drive, an ignition plug 37, and an ignition plug 37, and the injector (fuel-injection means) 39 which injects a fuel in an inlet port 31.

[0052] The induction system 40 is equipped with throttle-valve actuator 43a which constitutes the air filter 42 prepared in the edge of the inlet pipe 41 containing the intake manifold which is open for free passage to an inlet port 31, and forms an inhalation-of-air path with this inlet port 31, and an inlet pipe 41, the throttle valve 43 which is in an inlet pipe 41 and makes adjustable the opening cross section of an inhalation-of-air path, and a throttle-valve driving means, the swirl control valve (the following, "SCV", and nominal ****.) 44, and SCV actuator 44a.

[0053] If TAt is given whenever [target throttle valve-opening] by the electronics control throttle-valve logic which the electronic control 70 mentioned later attains, throttle-valve actuator 43a which consists of a DC motor will drive a throttle valve 43 so that TA may serve as [whenever / actual throttle valve-opening] TAt whenever [target throttle valve-opening].

[0054] SCV actuator 44a which consists of a DC motor receives a driving signal from an electrical control unit 70, is supported by said throttle valve 43 rotatable to said inlet pipe 41 on a lower stream of a river in an upstream location rather than said injector 39, and carries out revolution actuation of SCV44 for making the air inhaled in a combustion chamber generate a swirl rather than it.

[0055] The exhaust system 50 is equipped with the catalytic converter (three-way catalytic converter) 53 infixed in the exhaust pipe 52 connected to the exhaust manifold 51 which was open for free passage to the exhaust port 34, and the exhaust manifold 51, and the exhaust pipe 52.

[0056] On the other hand, this system is equipped with the heat ray type air flow meter 61, an intake temperature sensor 62, the atmospheric-pressure sensor (throttle-valve top fluid pressure force sensor) 63, a throttle position sensor 64, the SCV opening sensor 65, the cam position sensor 66, the crank position sensor 67, the coolant temperature sensor 68, the air-fuel ratio sensor 69, and the accelerator opening sensor 81 that constitutes an accelerator control input detection means (part).

[0057] The air flow meter 61 consists of the bypass path which makes a part of inhalation air which flows the inside of an inlet pipe 41 bypass, heat ray metering zone 61a which measures the mass flow rate of the inhalation air bypassed by this bypass path, and signal-processing section 61b which outputs the electrical potential difference Vg according to the measured mass flow rate, as shown in drawing 2 which is an outline perspective view. The resistance 61a1 for intake-air temperature measurement which consists of a platinum heat ray as heat ray metering zone 61a was shown in drawing 3 which is the amplification perspective view (bobbin section), It has the support section 61a2 which connects the resistance 61a1 for the said intake-air

temperature measurement with said signal-processing section 61b, and holds it, the resistance 61a3 for heating (heater), and the support section 61a4 which connects the resistance 61a3 for the said heating with said signal-processing section 61b, and holds it. Signal-processing section 61b is equipped with the bridge circuit which consisted of resistance 61a1 for intake-air temperature measurement, and resistance 61a3 for heating, and this power to supply is transformed into said electrical potential difference Vg, and it outputs it while it adjusts the power supplied to the resistance 61a3 for the said heating so that the temperature gradient of the resistance 61a1 for intake-air temperature measurement and the resistance 61a3 for heating may always be uniformly maintained by this bridge circuit. The output Vg of this air flow meter 61 and the relation with the measured intake air flow mtAFM are as having been shown in drawing 4 , and an electrical control unit 70 acquires the value of the measured intake air flow mtAFM by using the relation of this drawing 4 .

[0058] It has the intake temperature sensor 62 in the air flow meter 61, it detects the temperature (intake-air temperature) of inhalation air, and outputs the signal showing an intake-air temperature THA. The atmospheric pressure sensor 63 detects the pressure (namely, atmospheric pressure) of the upstream of a throttle valve 43, and outputs the signal showing the throttle-valve upstream pressure Pa. A throttle position sensor 64 detects the opening of a throttle valve 43, and outputs the signal with which TA is expressed whenever [throttle valve-opening]. The SCV opening sensor 65 detects the opening of SCV44, and outputs the signal showing SCV opening thetaiv. the cam position sensor 66 generates the signal (G2 signal) which has one pulse, whenever 90 degrees of intake cam shafts rotate, and 180 degrees of crankshafts 24 rotate namely,. The crank position sensor 67 outputs the signal which has a broad pulse, whenever 360 degrees of these crankshafts 24 rotate, while having a narrow pulse, whenever 10 degrees of crankshafts 24 rotate. This signal expresses an engine speed NE. A coolant temperature sensor 68 detects the temperature of an internal combustion engine's 10 cooling water, and outputs the signal showing the cooling water temperature THW. The air-fuel ratio sensor 69 outputs the signal which expresses an air-fuel ratio with detecting the oxygen density in the exhaust gas which flows into a catalytic converter 53. The accelerator opening sensor 81 detects the control input of the accelerator pedal 82 operated by the operator, and outputs the signal showing the control input Accp of this accelerator pedal.

[0059] The program which CPU71 and CPU71 to which the electrical control unit 70 of each other was connected by bus perform, A table (a look-up table, map), Where RAM73 and the power source in which ROM72 and CPU71 which memorized the constant etc. beforehand store data temporarily if needed are switched on, while storing data It is the microcomputer which consists of interface 75 grade containing the backup RAM 74 which holds the said-stored data also while the power source is intercepted, and an AD converter. an interface 75 -- said sensor 61- it connects with 69 and 81 -- having -- CPU71 -- sensor 61- while supplying the signal from 69 and 81, according to directions of this CPU71, a driving signal is sent out to actuator 33a of adjustable inhalation-of-air timing equipment 33, an ignitor 38, an injector 39, throttle-valve actuator 43a, and SCV actuator 44a.

[0060] Next, the decision approach of fuel oil consumption using the physical model by the control device constituted as mentioned above is explained. Processing described below is performed when CPU71 performs a program.

[0061] (Outline of the decision approach of fuel oil consumption fi) Such a fuel-oil-consumption control unit needs to inject the fuel of the specified quantity to this cylinder at the event before the event (at the time of inlet-valve clausilium) of the inlet valve 32 of the cylinder in an intake stroke or the cylinder (namely, fuel-injection cylinder) in the condition in front of an intake stroke shifting to the condition of closing the valve from the condition of having opened in the intake stroke. Therefore, when an inlet valve 32 shifts to a clausilium condition, this fuel-oil-consumption control unit predicts beforehand the inhalation air content which is probably inhaled in this cylinder, and injects the fuel of fuel quantity according to the said-predicted inhalation air content to this cylinder at the event before the time of the clausilium of this inlet valve 32. It sets to this example and is the before [an inhalation-of-air top dead center] 75-degree crank angle type (it expresses "BTDC75"CA" hereafter.) of a fuel-injection cylinder about an injection termination stage. It expresses similarly about other crank angle types. It has set. Therefore, this control device predicts the inhalation air content of a fuel-injection cylinder in consideration of the time amount (valve-opening time amount of an injector) which injection takes, and the computation time of CPU at the event before the event of BTDC75"CA.

[0062] On the other hand, the pressure-of-induction-pipe force at the time of inlet-valve clausilium (namely, air pressure in an inlet pipe) has an inhalation air content and a close relation. Moreover, it depends for the pressure-of-induction-pipe force at the time of inlet-valve clausilium on whenever [throttle valve-opening /

at the time of inlet-valve clausilium]. Then, as this control unit predicts and presumes whenever [throttle valve-opening / at the time of inlet-valve clausilium], predicts the inhalation air content KLfwd of a fuel-injection cylinder in advance based on whenever [throttle valve-opening] and showed it to the one following While determining the temporary fuel oil consumption (front [amendment] fuel oil consumption) fib by **(ing) with the target air-fuel ratio AbyFref to which the predicted inhalation air content KLfwd is separately set according to engine operational status The amount Ffb of fuel feedback amendments is calculated separately, the amount Ffb of fuel feedback amendments amends the fuel oil consumption Fib before amendment, and the fuel oil consumption fi of normal is calculated. The amount Ffb of fuel feedback amendments is a value based on the difference of the fuel quantity (real need fuel quantity) actually needed in the last intake stroke, and the fuel quantity (real inhalation fuel quantity) actually inhaled in the intake stroke of ******, as explained in full detail behind. The above is the outline of the approach of calculating the normal fuel oil consumption (amount of the fuel injected eventually) fi.

[0063]

[Equation 1] fi = KLfwd/AbyFref+Ffb= Fib+Ffb [0064] (A concrete configuration and operation) The concrete configuration of the fuel-oil-consumption control unit for calculating hereafter the fuel oil consumption fi shown in one above and an operation are explained. As this fuel-oil-consumption control device was shown in drawing 5 which is a functional block diagram The event before the electronics control throttle-valve logic A1 and this time An amount prediction means M1 of operational status to predict the amount of operational status of internal combustion engines, such as whenever [throttle valve-opening / at the event of the point], from the amount acquisition means A2 of operational status and this time which acquire the amount of operational status of internal combustion engines, such as whenever [in (the past - current) / actual throttle valve-opening], and a actual accelerator control input, As a real inhalation air content calculation means containing the air model which modeled the behavior of the air in an internal combustion engine's inhalation-of-air system The injection-quantity decision means A6 which showed the detailed functional block diagram is included in **** 1 inhalation air model A3, 2nd inhalation air model A4 as a prediction inhalation air content calculation means containing this air model, target air-fuel ratio setting-out means A5, and drawing 6 . Hereafter, each means, a model, etc. are explained individually concretely.

[0065] (Electronics control throttle-valve logic and electronics control throttle-valve model) The electronics control throttle-valve model M1 which predicts TAest first to be the electronics control throttle-valve logic A1 for controlling whenever [throttle valve-opening] whenever [in the future (it can set rather than this time at the event of the point) / throttle valve-opening] is explained.

[0066] First the electronics control throttle-valve logic A1 Operation period deltaTt It is based on the output value of the accelerator opening sensor 81 for every progress of (8msec [for example,]). The accelerator control input Accp Read in, Based on the table which specified relation with TAacc whenever [accelerator control input Accp and accelerator control input Accp of drawing 7 , and target throttle valve-opening], TAacc is calculated whenever [this provisional target throttle valve-opening]. [which were read] In TAacc, as shown in the timing diagram of drawing 8 whenever [this provisional target throttle valve-opening], only the predetermined time delay TD is delayed, TAacc is set [whenever / this provisional target throttle valve-opening / that was delayed] up as TAt whenever [target throttle valve-opening], and it outputs to throttle-valve actuator 43a. In addition, although a time delay TD is fixed time amount in this example, it can also make into the adjustable time amount according to an engine speed NE to consider as the time amount T270 taken for an internal combustion engine to rotate only whenever [predetermined crank angle] (for example, 270 degree CA of crank angles) etc.

[0067] By the way, even if it is the case where TAt is outputted to throttle-valve actuator 43a whenever [target throttle valve-opening] from the electronics control throttle-valve logic A1, according to the delay of this throttle-valve actuator 43a, the inertia of a throttle valve 43, etc., TA has a certain delay and is followed [whenever / actual throttle valve-opening] whenever [target throttle valve-opening] at TAt. Then, in the electronics control throttle-valve model M1, it is based on the two following, and whenever [after a time delay TD / throttle valve-opening] is predicted and presumed (see drawing 8).

[0068]

[Equation 2]

TAest(k+1) =TAest(k)+deltaTt-f (TAt (k), TAest (k)) [0069] It is TAest whenever [prediction throttle valve-opening / which sets TAest (k+1) to this operation timing, and is newly predicted and presumed in several 2]. TAt (k) is TAt whenever [target throttle valve-opening / which was newly obtained to this operation timing]. TAest (k) is TAest (TAest whenever [prediction and throttle valve-opening / which was

presumed] setting [Namely,] to the last operation timing) whenever [newest prediction throttle valve-opening / which set to this operation timing, and was already predicted and presumed]. Moreover, Function f (TAt (k), TAest (k)) is a function (the function f which carries out a monotonous increment about deltaTA) which takes such a large value that difference deltaTA (=TAt(k)-TAest (k)) of TAt (k) and TAest (k) is large as shown in drawing 9 .

[0070] Thus, it memorizes and stores at RAM73 in the form where newly predicted and presumed TAest whenever [after a time delay TD / throttle valve-opening] while the electronics control throttle-valve model M1 (CPU71) newly determined TAt to this operation timing whenever [after a time delay TD / target throttle valve-opening], and TAest was made to correspond [whenever / target throttle valve-opening / of an after / the time delay TD progress from this time] to the time amount progress from this time whenever [TAt and prediction throttle valve-opening].

[0071] 1st inhalation air model A3 of <1st inhalation air model (real inhalation air content calculation means) A3> It has the throttle model M2 which constitutes the air model which modeled the behavior of the air in an internal combustion engine's inhalation-of-air system, the inlet-valve model M3, the inlet-pipe model M4, and the inlet-valve model M5. Are at the event after the time of the inlet-valve clausilium in the last intake stroke of a specific cylinder, and the real inhalation air content KLact which is a actual inhalation air content at the time of the inlet-valve clausilium in the last intake stroke of this cylinder at the event before the time of the inlet-valve clausilium to this intake stroke of this cylinder It asks based on whenever [actual throttle valve-opening / which is the actual amount of operational status acquired by said amount acquisition means A2 of operational status] (whenever [real throttle valve-opening] TAact). The content of the above-mentioned throttle model M2, the inlet-valve model M3, the inlet-pipe model M4, and the inlet-valve model M5 is explained in full detail behind.

[0072] In addition, although the actual inhalation air content KLact is calculated in this example with the throttle model M2, the inlet-valve model M3, the inlet-pipe model M4, and the inlet-valve model M5 Apart from this, whenever [real throttle valve-opening / at the time of the inlet-valve clausilium in the last intake stroke of a fuel-injection cylinder] TAact, The real engine speed NE at the time of the inlet-valve clausilium in the last intake stroke of this fuel-injection cylinder, And the actual inhalation air content KLact may be calculated using a table (table which specified beforehand the relation of TAacc, an engine speed NE, and the real inhalation air content KLact whenever [throttle valve-opening]), or a formula.

[0073] 1st inhalation air model A4 of <2nd inhalation air model A4> It has the throttle model M20 which constitutes the air model which 1st inhalation air model A3 contains, and the same air model, the inlet-valve model M30, the inlet-pipe model M40, and the inlet-valve model M50. Based on TAest, the inhalation air content KLfwd at the time of the inlet-valve clausilium in this intake stroke of this fuel-injection cylinder (prediction inhalation air content) is predicted and presumed whenever [prediction throttle valve-opening / which was predicted and presumed with the electronics control throttle-valve model M1 at least]. The above-mentioned throttle model M20, the inlet-valve model M30, the inlet-pipe model M40, and the inlet-valve model M50 are explained in full detail behind.

[0074] 1st air model A3 whenever [prediction throttle valve-opening / at the time of the inlet-valve clausilium in this intake stroke of a fuel-injection cylinder] In addition, TAest, The real engine speed NE at the time of the inlet-valve clausilium in this intake stroke of this fuel-injection cylinder, and the prediction inhalation air content KLfwd at the time of the inlet-valve clausilium in this intake stroke is calculated using a table (table which specified the relation between TA, an engine speed NE, and an inhalation air content whenever [throttle valve-opening]) (it predicts) -- it may be constituted like.

[0075] <Target air-fuel ratio setting-out means A5> target air-fuel ratio setting-out means are the engine speed NE which is an internal combustion engine's operational status, and a means to determine the target air-fuel ratio AbyFref based on TAt etc. whenever [target throttle valve-opening]. This target air-fuel ratio AbyFref may be set as theoretical air fuel ratio except for the case of being special, after an internal combustion engine's warming-up termination.

[0076] The injection-quantity decision means A6 shown in <injection-quantity decision means A6> drawing 5 The real inhalation air content KLact at the time of the inlet-valve clausilium in the last intake stroke of the specific cylinder computed by 1st inhalation air model A3 The prediction inhalation air content KLfwd at the time of the inlet-valve clausilium in this intake stroke of this specific cylinder computed by 2nd inhalation air model A4 And it is a means to determine the normal fuel oil consumption fi to this intake stroke of this specific cylinder (k) based on the target air-fuel ratio AbyFref determined by target air-fuel ratio setting-out means A5. This injection-quantity decision means A6 is equipped with the prediction need fuel-quantity calculation means A51, the fuel-oil-consumption calculation means A52 before amendment

(fuel behavior reverse model), the real need fuel-quantity calculation means A53, the real inhalation fuel-quantity calculation means (the order model of fuel behavior) A54, the amount calculation means A55 of fuel feedback amendments, and a fuel-oil-consumption calculation means (a normal fuel-oil-consumption calculation means) A56 as a detail was shown within limits surrounded with the broken line of drawing 6 . Hereafter, explanation is added according to an individual about the means with which the fuel-oil-consumption decision means A6 is equipped, and a model.

[0077] (Prediction need fuel quantity calculation means A51) The prediction need fuel quantity calculation means A51 is a means to calculate the prediction need fuel quantity Fcfwd by what (KLfwd/AbyFref) the prediction inhalation air content KLfwd at the time of the inlet-valve clausilium in this intake stroke of said specific cylinder called for by 2nd inhalation air model A4 is **(ed) for with the target air-fuel ratio AbyFref asked by target air-fuel ratio setting-out means A5. That is, this prediction need fuel quantity Fcfwd is an amount of the fuel which should be inhaled by this specific cylinder, in order to make into the target air-fuel ratio AbyFref the air-fuel ratio of the gaseous mixture inhaled in this intake stroke of said specific cylinder.

[0078] (Front [amendment] fuel-oil-consumption calculation means A52 (fuel behavior reverse model)) The fuel-oil-consumption calculation means A52 before amendment The amount of the fuel inhaled in a cylinder, without adhering to the inhalation-of-air system of an inlet port or an inlet valve among the injected fuels using the reverse model of fuel behavior and the amount of the fuel inhaled in a cylinder among the fuels adhering to an inhalation-of-air system are taken into consideration. It is a means to compute the fuel oil consumption Fib before amendment (k) needed in order to supply the fuel quantity of said prediction need fuel quantity Fcfwd to a fuel-injection cylinder.

[0079] If the reverse model of said fuel behavior model is explained, will be after the intake stroke of the last time of a specific cylinder, and it will set here just before this intake stroke. The prediction port fuel coating weight predicted to have adhered to the inlet port of this cylinder fwpi (k), The prediction bulb fuel coating weight predicted to have adhered to the inlet valve of this cylinder fwvi (k), When setting [the fuel deposit efficiency to an inlet port / Rpi and the fuel deposit efficiency to an inlet valve] Ppi and fuel residual percentage to an inlet valve to Pvi for Rvi and the fuel residual percentage to an inlet port, When the fuel of the fuel oil consumption Fib before amendment (k) is injected to this intake stroke of this cylinder, the fuel quantity Fin inhaled by this cylinder is expressed with the three following.

[0080]

[Equation 3] Fin= (1-Rpi-Rvi), Fib(k)+ (1-Ppi), fwpi(k)+ (1-Pvi), and fwvi -- (k [0081]) Therefore, in order for the prediction need fuel quantity Fcfwd to be inhaled by this specific cylinder in this intake stroke of a specific cylinder, the above-mentioned fuel quantity Fin will be placed if equal to the prediction need fuel quantity Fcfwd, and a count result serves as a passage with the four following that what is necessary is just to calculate the fuel oil consumption Fib before amendment (k). This several 4 mathematizes the reverse model of fuel behavior.

[0082]

[Equation 4] Fib (k) =(Fcfwd- (1-Ppi), fwpi(k)- (1-Pvi), and fwvi (k))/(1-Rpi-Rvi) [0083] It is the prediction inhalation air content KLfwd at the time of the inlet-valve clausilium which used the fuel-oil-consumption calculation means A52 before amendment for calculation of the prediction inhalation air content KLfwd (). Or the engine speed NE (however, the engine speed NE at the time of prediction inhalation air content KLfwd calculation may be used noting that there are few amounts which change into a short time.) as which it is predicted at the time of TAest and inlet-valve close whenever [prediction throttle valve-opening / at the time of inlet-valve close / this] And the inlet-valve closing motion timing VT of being predicted at the time of inlet-valve close (however, the inlet-valve closing motion timing VT at the time of prediction inhalation air content KLfwd calculation may be used noting that there are few amounts which change into a short time.) etc. -- it is based, and asks for the fuel deposit efficiency Rpi to an inlet port, the fuel deposit efficiency Rvi to an inlet valve, the fuel residual percentage Ppi to an inlet port, and the fuel residual percentage Pvi to an inlet valve, and the fuel oil consumption Fib before amendment (k) is calculated using these and four above.

[0084] Moreover, the operation of the fuel oil consumption Fib (k+1) before amendment to the intake stroke of this next specific cylinder is equipped with the fuel-oil-consumption calculation means A52 before amendment. The prediction port fuel coating weight which is after the intake stroke of this time of this cylinder, and is predicted to have adhered before a next intake stroke in the inlet port of this cylinder fwpi (k+1), And the prediction bulb fuel coating weight which is after the intake stroke of this time of this cylinder, and is predicted to have adhered to the inlet valve of this cylinder in front of a next intake stroke is

calculated for fwvi (k+1) based on the five following and the six following.
[0085]
[Equation 5] fwpi(k+1) = Ppi-fwpi(k)+Rpi-Fib -- (k [0086])
[Equation 6] fwvi(k+1) = Pvi-fwvi(k)+Rvi-Fib -- (k [0087]) (Real need fuel quantity calculation means A53) The real need fuel quantity calculation means A53 The real inhalation air content KLact at the time of the inlet-valve clausilium in the last intake stroke of said specific cylinder called for by 1st inhalation air model A3 By what (KLact/AbyFref) is **(ed) with the target air-fuel ratio AbyFref set up by target air-fuel ratio setting-out means A5 It is a means to calculate the real need fuel quantity Fcact which is the fuel quantity which was required in order to make an air-fuel ratio into the target air-fuel ratio AbyFref in the last intake stroke of this specific cylinder.
[0088] (Real inhalation fuel quantity calculation means A54 (the order model of fuel behavior)) The real inhalation fuel quantity calculation means A54 The fuel actually injected to the last intake stroke of a specific cylinder using the order model of fuel behavior, Namely, the amount of the fuel inhaled by this cylinder, without adhering to an inhalation-of-air system among the fuels of the fuel oil consumption fi (k-1) of the last normal and the amount of the fuel inhaled in the cylinder of this cylinder among the fuels adhering to an inhalation-of-air system are taken into consideration. It is a means to calculate the real inhalation fuel quantity Fcest which is the fuel quantity actually inhaled in the cylinder of this cylinder in the last intake stroke of this cylinder.
[0089] If the order model of fuel behavior is explained, will be after the intake stroke of the second from last time of a specific cylinder, and it will set here just before the last intake stroke. The port fuel coating weight adhering to the inlet port of this cylinder fwp (k-1), When setting [the bulb fuel coating weight adhering to the inlet valve of this cylinder / fwv (k-1) and the fuel deposit efficiency to an inlet port / Rp and the fuel deposit efficiency to an inlet valve] Pp and fuel residual percentage to an inlet valve to Pv for Rv and the fuel residual percentage to an inlet port, The port fuel coating weight fwp (k) which is after the intake stroke of the last time of this cylinder, and had adhered to the inlet port of this cylinder actually just before this intake stroke, and the bulb fuel coating weight fwv (k) which had adhered to the inlet valve of this cylinder actually are calculated by the seven following and the eight following.
[0090]
[Equation 7] fwp (k) = Pp-fwp(k-1)+Rp-fi (k-1) [0091]
[Equation 8] fwv (k) = Pv-fwv(k-1)+Rv-fi (k-1) [0092] Therefore, in the last intake stroke of a specific cylinder, the real inhalation fuel quantity Fcest actually inhaled by this cylinder is calculated by the nine following. Seven above - a-nine number are the formulas showing the order model of fuel behavior.
[0093]
[Equation 9] Fcest = fi(k-1) -(fwp(k)-fwp(k-1))-(fwv(k)-fwv(k-1))
[0094] The real inhalation fuel quantity calculation means A54 In addition, the fuel deposit efficiency Rp to an inlet port, Actual fuel deposit efficiency [to an inlet valve] Rv, fuel residual percentage [to an inlet port] Pp, and fuel residual percentage Pv to inlet valve inhalation-air content KLact at the time of the inlet-valve clausilium in the last intake stroke () Or it is the actual engine speed NE (however, the engine speed NE at the time of real inhalation air content KLact calculation is sufficient.) at the time of this inlet-valve clausilium whenever [actual throttle valve-opening / at the time of inlet-valve close / this]. It determines based on the actual inlet-valve closing motion timing VT at the time of inlet-valve close [this] (however, the inlet-valve closing motion timing VT at the time of real inhalation air content KLact calculation may be used.) etc. And this determined deposit efficiency and residual percentage, Based on seven above - nine above, the real inhalation fuel quantity Fcest is computed for every cylinder.
[0095] (The amount calculation means A55 of fuel feedback amendments) The amount calculation means A55 of fuel feedback amendments is a means to calculate the amount Ffb of fuel feedback amendments (k) based on "the difference Fcerr showing a part for the excess and deficiency of the fuel in the last intake stroke of a specific cylinder of the real need fuel quantity Fcact and the real inhalation fuel quantity Fcest" (k), i.e., an inhalation fuel quantity error. In this example, the amount calculation means A55 of fuel feedback amendments is PI (proportion and integral) controller, and it calculates the amount Ffb of fuel feedback amendments (k) by the 11 following and the 12 following while it searches for the inhalation fuel quantity error Fcerr (k) by the ten following. SumFcerr of the 11 following and the 12 following is the integral value of the inhalation fuel quantity error Fcerr. A multiplier Kp and a multiplier Ki are a proportionality constant and an integration constant, respectively.
[0096]
[Equation 10] Fcerr(k) =Fcact-Fcest [0097]

[Equation 11] Ffb(k) =Kp-Fcerr(k)+Ki-SumFcerr (k-1) [0098]
[Equation 12] SumFcerr(k) =SumFcerr(k-1)+Fcerr(k) [0099] (Fuel-oil-consumption calculation means A56) The fuel-oil-consumption calculation means A56 is a means for the amount Ffb of fuel feedback amendments (k) to amend the fuel oil consumption Fib before amendment (k) calculated as mentioned above, and to calculate this normal fuel oil consumption fi of a specific cylinder (k). As shown in the 13 same following as one above, specifically, the value amount [of fuel feedback amendments] Ffb (k) applied to the fuel oil consumption Fib before amendment (k) is calculated as normal fuel oil consumption fi (k).
[0100]
[Equation 13] fi(k) =Fib(k)+Ffb -- (k [0101]) Here, it explains, referring to drawing 10 illustrating each stroke and count timing of a specific cylinder about the count timing of each means of the above-mentioned injection-quantity decision means A6. First, considering the case where the injection quantity fi of the fuel injection A to the intake stroke A of this intake stroke (k) is determined, it is at the event after B at the time of the inlet-valve clausilium to the last intake stroke B, and the real inhalation air content KLact is computed by 1st inhalation air model A3 at the event before A (at the 3rd predetermined event) at the time of the inlet-valve clausilium to this intake stroke A. When supplying a fuel by fuel injection A to this intake stroke A, it is desirable at the 3rd predetermined event that it is at the event before initiation of this fuel injection A.
[0102] At subsequently, the 4th predetermined event which it is at the event after said 3rd predetermined event, and at the predetermined event before A at the time of the inlet-valve clausilium to this intake stroke A of said cylinder The real need fuel quantity Fcact which is the fuel quantity actually needed for this cylinder in the last intake stroke B of this cylinder based on the real inhalation air content KLact computed by the real need fuel quantity calculation means A53 is computed.
[0103] And the event of being a front [A] at the time of the inlet-valve clausilium to this intake stroke A, and the fuel oil consumption of the normal to the last intake stroke B being decided At the 5th predetermined event after (for example, the last normal fuel-oil-consumption fi (k-1) calculation event) The real inhalation fuel quantity Fcest which is the fuel quantity which this cylinder inhaled actually in the last intake stroke of this cylinder is computed based on the fuel oil consumption (normal fuel oil consumption) fi (k-1) actually injected to the last intake stroke B of this cylinder.
[0104] It is at the event after the this 4th predetermined and 5th predetermined event, and the amount Ffb of fuel feedback amendments (k) is computed by the amount calculation means A55 of fuel feedback amendments based on said computed real need fuel quantity Fcact and said computed real inhalation fuel quantity Fcest at the 6th predetermined event before A at the time of the inlet-valve clausilium to this intake stroke A.
[0105] On the other hand, the prediction inhalation air content KLfwd which is an inhalation air content of A at the time of the inlet-valve clausilium in this intake stroke A of this cylinder is computed by prediction inhalation air content calculation means A4 at the 1st predetermined event before A at the time of the inlet-valve clausilium to this intake stroke A of a specific cylinder. If it is at the 1st predetermined event at the event before A at the time of the inlet-valve clausilium to this intake stroke A, although it is good always, in order to raise the predictability of the prediction inhalation air content KLfwd, when close to A, it is theoretically desirable at the time of this inlet-valve clausilium as much as possible. Actually, just before [at the initiation event of this injection A] is suitable at the 1st predetermined event.
[0106] Moreover, it is at the event after the 1st predetermined event, and the fuel oil consumption Fib before amendment (k) which is temporary injection quantity which should be injected to this intake stroke A of this cylinder with the fuel-oil-consumption calculation means A52 before amendment based on said prediction inhalation air content KLfwd at the 2nd predetermined event before A is computed at the time of the inlet-valve clausilium to this intake stroke A of said cylinder. In addition, you may be at the 1st predetermined and 2nd predetermined event at the event before the 3rd [**] - 5th predetermined event.
[0107] Are at the event after said said 2nd predetermined and 6th predetermined event, and at the 7th predetermined event before A at the time of the inlet-valve clausilium to this intake stroke A of said cylinder and with the fuel-oil-consumption calculation means A56 The fuel oil consumption Fib before said computed amendment (k) is amended by said computed amount Ffb of fuel feedback amendments (k). The fuel oil consumption fi of the normal which should be injected to this intake stroke A of this cylinder (k) is computed. Directions are made so that only the fuel oil consumption fi of this normal (k) may inject a fuel at the 8th predetermined event which it is at the event after this 7th predetermined event, and at the event before A at the time of the inlet-valve clausilium to this intake stroke A, and thereby, fuel injection A is performed. the above actuation -- the intake stroke of the arbitration of one cylinder -- said -- it is carried out

between the following intake strokes following the intake stroke of this arbitration of one cylinder.
[0108] Next, 1st inhalation air model A3 mentioned above and 2nd inhalation air model A4 are explained to a detail. As shown in drawing 5 , 1st inhalation air model A3 is equipped with models M2-M5. 2nd inhalation air model A4 contains the same models M20-M50 corresponding to models M2-M5, respectively, and only the parameter (it inputs) to be used differs from 1st inhalation air model A3. Therefore, hereafter, 1st inhalation air model A3 is mainly explained, and only a point of difference with 1st inhalation air model A3 is explained about 2nd inhalation air model A4.
[0109] (Throttle model M2) The throttle model M2 is a model which presumes the air flow rate (throttle passage air flow rate) mt which passed the throttle valve 43 based on the 14 following obtained based on physical laws, such as the law of conservation of energy, a law of conservation of momentum, a law of mass conservation, and an equation of state. The flow coefficient from which Ct (thetat) changes in the 14 following according to thetat (=TA) whenever [throttle valve-opening], The throttle opening area from which At (thetat) changes according to thetat (=TA) whenever [throttle valve-opening] (opening area of an inlet pipe 41), For the air temperature in an inlet pipe, and R, a gas constant and kappa are [Pa / a throttle-valve upstream pressure (namely, atmospheric pressure) and Pm / the pressure-of-induction-pipe force (air pressure in an inlet pipe), and Ta / an intake-air temperature (atmospheric temperature) and Tm] the ratio of specific beat (kappa is hereafter treated as constant value.). it is .
[0110]
[Equation 14]

$$mt = Ct(\theta t)At(\theta t)Pa\sqrt{\frac{\kappa+1}{2\kappa RTa}}\sqrt{\left(\frac{\kappa}{\kappa+1}\right)^2-\left(\frac{Pm}{Pa}-\frac{1}{\kappa+1}\right)^2}$$

[0111] Here, a derivation process with 14 above which described the above-mentioned throttle model M2 is explained. When the opening cross section of the upstream of a throttle valve 43 is set to Au, the rate of flow of rhou and air is set to vu for air density and the rate of flow of the air which passes [the opening cross section of the inlet pipe 41 by the throttle valve 43] rhod and a throttle valve 43 for the air density of Ad and a there is now set to vd, the throttle passage air flow rate mt is expressed with the 15 following. Several 15 can be said to be the formula which described the law of mass conservation.
[0112]
[Equation 15] Mt=Ad-rho d-vd=Au-rho u-vu [0113] On the other hand, when mass of air is set to m, kinetic energy is m-vu 2/2 in the upstream of a throttle valve 43, and is m-vd 2/2 in the location which passes a throttle valve 43. On the other hand, heat energy is m-Cp-Tu in the upstream of a throttle valve 43, and m-Cp-Td in the location which passes a throttle valve 43. Therefore, the 16 following are obtained by the law of conservation of energy. In addition, Tu is [the air temperature of a throttle-valve lower stream of a river and Cp of the air temperature of the throttle-valve upstream and Td] specific heat at constant pressure.
[0114]
[Equation 16]
m-vu2/2+m-Cp-Tu=m-vd2 / 2+m-Cp-Td [0115] By the way, since the 17 following and the ratio of specific beat kappa are shown by the 18 following and Mayer's relation is shown by the 19 following, an equation of state is expressed for Cp-T like [with the 20 following] from several 17 - a-19 number. In addition, for a gaseous pressure and rho, a gaseous consistency and T are [P / a gas constant and Cv of gaseous temperature and R] specific heat at constant volume.
[0116]
[Equation 17] P=rho-R-T [0117]
[Equation 18] Kappa=Cp/Cv [0118]
[Equation 19] Cp=Cv+R [0119]
[Equation 20] Cp-T= {kappa/(kappa-1)} - (P/rho) [0120] The 21 following will be obtained if several 16 based on the above-mentioned law of conservation of energy is rewritten using relation with 20 above. Here, Pu is the air pressure of the throttle-valve 43 upstream, and Pd is the air pressure (namely, pressure-of-induction-pipe force Pm) of the lower stream of a river of a throttle valve 43.
[0121]
[Equation 21] vu2/2+{kappa/(kappa-1)} -(Pu/rhou) =vd2/2+{kappa/(kappa-1)} - (Pd/rhod) [0122] And considering the infinity upstream of a throttle valve 43, since it is Au=infinity and vu=0, 21 above based on the law of conservation of energy is rewritten by the 22 following.
[0123]
[Equation 22] {kappa/(kappa-1)} -(Pu/rhou) =vd2 / 2+ {kappa/(kappa-1)} - (Pd/rhod) [0124] Next,

momentum is described. The 23 following will be obtained if the mean pressure of the fixed space which connects between the parts of Pd and the cross section Au and the parts of the cross section Ad for the pressure which joins the parts of Pu and the cross section Ad in the pressure which joins the part of the cross section Au is set to Pmean.
[0125]
[Equation 23] rhod-vd2, Ad-rhou-vu2, andAu=Pu-Au-Pd-Ad+Pmean- (Ad-Au)
[0126] If Au=infinity and vu=0 are taken into consideration, since the 24 following will be obtained by 23 above, the relation (relation based on a law of conservation of momentum) about momentum with the same number 24 and 23 above to the 25 following is obtained.
[0127]
[Equation 24] Pmean=Pu [0128]
[Equation 25] rhod-vd2=Pu-Pd [0129] Therefore, the 26 following are obtained from 15 above, 22 above, and several 25.
[0130]
[Equation 26]

$$mt = Ad\sqrt{Pu\cdot\rho u}\sqrt{\left(\frac{Pd}{Pu}+\frac{1}{2}\frac{\kappa-1}{\kappa}\left(1-\frac{Pd}{Pu}\right)\right)\left(1-\frac{Pd}{Pu}\right)}$$

[0131] In 26 above, Pu is the throttle-valve upstream pressure Pa, and Pd is the pressure-of-induction-pipe force Pm. Moreover, 14 above will be obtained, if the opening cross section Ad is replaced with the opening area A (thetat), a flow coefficient is further applied for Ct (thetat) and 26 above is arranged, while substituting rhou=M/Vu=Pu/(R-Tu) for 26 above from an equation of state.
[0132] Next, if how to calculate the throttle passage air flow rate mt in the throttle model M2 is described, 14 above is expressed by the 27 following and the 28 following, k1 is set with Ct(thetat) andAt(thetat) - {Pa / (R-Ta) 1/2}, and the 27 following will be rewritten by the 29 following when making mts into the throttle passage air flow rate at the time of inlet-valve clausilium.
[0133]
[Equation 27] mt=Ct(thetat) andAt(thetat) - {Pa / (R-Ta) 1/2} -phi (Pm/Pa) [0134]
[Equation 28]

$$\Phi\,(Pm/Pa) = \sqrt{\frac{\kappa+1}{2\kappa}}\sqrt{\left(\frac{\kappa}{\kappa+1}\right)^2-\left(\frac{Pm}{Pa}-\frac{1}{\kappa+1}\right)^2}$$

[0135]
[Equation 29] mts=k1andphi (Pm/Pa) [0136] Moreover, in several 29, if mtsTA and the pressure-of-induction-pipe force at that time are set to PmTA for a throttle passage air flow rate in case an internal combustion engine 10 is in a steady state (when changing with throttle valve-opening regularity and resulting in inlet-valve clausilium), since the 30 following will be obtained, a multiplier k1 can be eliminated from several 29 and several 30, and the 31 following can be obtained.
[0137]
[Equation 30] mtsTA=k1andphi (PmTA/Pa)
[0138]
[Equation 31]
mts= {mtsTA/phi (PmTA/Pa)} -phi (Pm/Pa)
[0139] If the value mtsTA in the right-hand side with 31 above is a value concerning the intake air flow (throttle passage air flow rate) in the steady operation condition that TA is fixed, whenever [throttle valve-opening] and is in such a steady operation condition, the throttle passage air flow rate mt and the intake air flow mc in a cylinder become equal. Then, only operation period delta Tt calculates the intake air flow mc in a cylinder at the last event from this time using the formula (the 32 following) obtained by the rule of thumb used with the inlet-valve model M3 mentioned later, and the throttle model M2 makes this a value mtsTA. In addition, the actual value in front of operation period deltaTt is used for each parameter (an engine speed NE and inlet-valve closing motion timing VT) at the time of calculating this value mtsTA (intake air flow mc in = cylinder) from total **** this time.
[0140] The throttle model M2 whenever [throttle valve-opening] Moreover, TA, an engine speed NE, and closing motion timing VT of an inlet valve The table MAPPM which specifies relation with the pressure-of-induction-pipe force Pm is memorized in ROM72. Whenever [actual throttle valve-opening / which was

detected in front of operation period deltaTt from this time] (whenever [real throttle valve-opening]) TAact (k-1), The actual engine speed NE in front of [this time to] operation period deltaTt, and the closing motion timing VT of the actual inlet valve in front of [this time to] operation period deltaTt Based on said table MAPPM, the pressure-of-induction-pipe force PmTA in the right-hand side with 31 above (=MAPPM (TAact (k-1), NE, VT)) is searched for.
[0141] Furthermore, the throttle model M2 has memorized table MAPphi which specifies the relation between value Pm/Pa and a value phi (Pm/Pa), and calculates the value (PmTA/Pa) which **(ed) said pressure-of-induction-pipe force PmTA by the throttle-valve upstream pressure Pa, and the value phi in the right-hand side with said table MAPphi to 31 above (PmTA/Pa) (=MAPphi (PmTA/Pa)). Similarly, the throttle model M2 calculates the value (Pm (k-1)/Pa) to which the inlet-pipe model M4 mentioned later ** (ed) the last pressure-of-induction-pipe force Pm (k-1) already searched for by the throttle-valve upstream pressure Pa, and the value phi in the right-hand side with said table MAPphi to 31 above (Pm/Pa) (=MAPphi (Pm (k-1)/Pa)). By the above, since each factor of the right-hand side with 31 above is called for, the throttle passage air flow rate mts (= mt (k-1)) is calculated by multiplying these.
[0142] (Inlet-valve model M3) The inlet-valve model M3 is a model which presumes the intake air flow mc in a cylinder from Tm, an intake-air temperature THA, etc. whenever [pressure-of-induction-pipe force Pm and inlet-pipe internal temperature]. Since it can consider that the cylinder internal pressure at the time of inlet-valve clausilium is the pressure Pm of the upstream of an inlet valve 32, i.e., the pressure-of-induction-pipe force at the time of inlet-valve clausilium, the intake air flow mc in a cylinder is proportional to the pressure-of-induction-pipe force Pm at the time of inlet-valve clausilium. Then, the inlet-valve model M3 calculates the intake air flow mc in a cylinder according to the 32 following based on a rule of thumb.
[0143]
[Equation 32] mc=(THA/Tm) and (c-Pm-d)
[0144] In several 32, a value c is an amount corresponding to a proportionality coefficient and the amount of burned gas to which the value d remained in the cylinder. The inlet-valve model M3 An engine speed NE and the closing motion timing VT of an inlet valve The tables MAPC and MAPD which specify the relation between a proportionality coefficient c and the amount d of burned gas, respectively are stored in ROM72. The actual engine speed NE in front of [this time to] operation period deltaTt, A proportionality coefficient c (=MAPC (NE, VT)) and the amount d of burned gas (=MAPD (NE, VT)) are calculated from the closing motion timing VT of the actual inlet valve in front of [this time to] operation period deltaTt, and said stored table. Moreover, the inlet-valve model M3 applies the pressure-of-induction-pipe force Pm (=Pm (k-1)) at the time of inlet-valve clausilium just before already being presumed with the inlet-pipe model M4 later mentioned at the operation event (newest), and the last air temperature Tm (= Tm (k-1)) in an inlet pipe to 32 above, and presumes the intake air flow mc (= mc (k-1)) in a cylinder at the time of inlet-valve clausilium.
[0145] (Inlet-pipe model M4) The inlet-pipe model M4 is a model which calculates the pressure-of-induction-pipe force Pm and the air temperature Tm in an inlet pipe from the air flow rate mc (namely, intake air flow in a cylinder) which flows out of the 33 following based on a law of mass conservation and the law of conservation of energy and the 34 following, the throttle passage air flow rate mt, the throttle passage air temperature (namely, inhalation air temperature THA) Ta, and an inlet pipe, respectively. In addition, in the 33 following and the 34 following, Vm is the volume of the inlet pipe 41 (they are only the "inlet-pipe section" and nominal **** hereafter.) from a throttle valve 43 to an inlet valve 32.
[0146]
[Equation 33] d(Pm/Tm)/dt=(R/Vm) and (mt-mc) [0147]
[Equation 34] DPm/dt=kappa, (R/Vm), and (mt-Ta-mc-Tm) [0148] The inlet-pipe model M4 acquires the throttle passage air flow rate mt (= mt (k-1)) in the right-hand side with 33 above and 34 above from the throttle model M2, and acquires the intake air flow mc (= mc (k-1)) in a cylinder from the inlet-valve model M3. And count based on several 33 and several 34 is performed, and the newest pressure-of-induction-pipe force Pm (= Pm (k)) and the air temperature Tm (= Tm (k)) in an inlet pipe are presumed.
[0149] Here, the derivation process of several 33 and several 34 which described the above-mentioned inlet-pipe model M4 is explained. If the total air content of the inlet-pipe section is now set to M, since the temporal response of the total air content M is the difference of the intake air flow mc in a cylinder equivalent to the throttle passage air flow rate mt equivalent to the air content which flows into the inlet-pipe section, and the air content which flows out of this inlet-pipe section, the 35 following based on a law of mass conservation will be obtained.
[0150]

[Equation 35] dM/dt=mt-mc [0151] Moreover, since an equation of state becomes the 36 following, 33 above based on a law of mass conservation is obtained by eliminating the total air content M from 35 above and the 36 following.
[0152]
[Equation 36] Pm-Vm=M-R-Tm [0153] Next, if the law of conservation of energy about the inlet-pipe section is examined, it will be thought that the volume Vm of the inlet-pipe section does not change, and most energy contributes it to a temperature rise in this case (kinetic energy can be disregarded). Therefore, since the amount of temporal responses of energy M-Cv-Tm of the air of the inlet-pipe section is equal to the difference of energy Cp-mt-Ta of the air which flows into this inlet-pipe section, and energy Cp-mc-Tm of the air which flows out of this inlet-pipe section, the 37 following are obtained.
[0154]
[Equation 37] d(M-Cv-Tm)/dt=Cp-mt-Ta-Cp-mc-Tm [0155] 34 above is obtained by transforming this several 37 using 18 (kappa=Cp/Cv) above and 36 (Pm-Vm=M-R-Tm) above.
[0156] The inlet-valve model M5 contains the same model as the above-mentioned inlet-valve model M3. (Inlet-valve model M5) The newest pressure-of-induction-pipe force Pm (=Pm (k)) which the inlet-pipe model M4 computed here, and the air temperature Tm (= Tm (k)) in an inlet pipe, The engine speed NE at present and the closing motion timing VT of an inlet valve at present Several 32 based on said Map MAPC, said map MAPD, and above-mentioned rule of thumb (the newest intake air flow mc (= mc (k)) in a cylinder is calculated using mc=(THA/Tm) and (c-Pm-d).) And the inlet-valve model M5 calculates the inhalation air content KLact by multiplying by the time amount Tint after an inlet valve 32 opens to the calculated intake air flow mc in a cylinder in the last intake stroke B computed from the engine speed NE until it closes the valve. In addition, the inlet-valve model M5 outputs the inhalation air content KLact calculated according to each cylinder immediately after at the time of the inlet-valve clausilium of a **** cylinder to the injection-quantity decision means A6 as a actual inhalation air content (real inhalation air content) KLact0 of a **** cylinder while performing such an operation for every cylinder.
[0157] As explained, as mentioned above, 1st inhalation air model A3 It is at the 3rd predetermined event before A (actually) at the time of inlet-valve clausilium [as opposed to / are at the event after B at the time of the inlet-valve clausilium in the last intake stroke B of a specific cylinder, and / this intake stroke (degree) A of this cylinder]. The real inhalation air content KLact which is a actual inhalation air content of B at the time of the inlet-valve clausilium in the last intake stroke B of this cylinder at the event just behind the inlet-valve clausilium to an intake stroke B It computes based on the actual amount of operational status acquired by the throttle position sensor 76 which is the amount acquisition means A2 of operational status, i.e., the air model which modeled the behavior of the air in the inhalation-of-air system of the internal combustion engine which consists of TAact and models M2-M5 whenever [real throttle valve-opening].
[0158] 2nd inhalation air model (2nd air model) A4 of <2nd inhalation air model A4> is the air model of the 1st inhalation air model which modeled the behavior of the air in an internal combustion engine's inhalation-of-air system, and the same model, and is equipped with the throttle model M20, the inlet-valve model M30, the inlet-pipe model M40, and the inlet-valve model M50. In order that this 2nd inhalation air model A4 may predict the inhalation air content KLfwd of A at the time of the inlet-valve clausilium of this intake stroke A, to 1st inhalation air model A3 inputting TAact whenever [real throttle valve-opening], it is the point of inputting TAest whenever [prediction throttle valve-opening / which is presumed with the electronics control throttle-valve model M1 mentioned above], and differs from this 1st inhalation air model A3.
[0159] (Throttle model M20) The throttle model M20 is based on 31 above, and predicts the throttle passage air flow rate mt at the future event (predetermined time TD, for example, a time delay, back). Also in this case, since it is thought that mtsTA of the right-hand side with 31 above is equal to the intake air flow mc in a cylinder, the equivalent mtsTA is calculated by 32 above used with the inlet-valve model M30 mentioned later. In addition, let each parameter at the time of calculating a value mtsTA (an engine speed NE and inlet-valve closing motion timing) for convenience be a value in this time.
[0160] Moreover, the throttle model M20 finds the time amount of just before a fuel-injection initiation stage (BTDC90"CA) to the time of inlet-valve clausilium from an engine speed NE, reads TAest from RAM72 whenever [after the time delay which carries out abbreviation coincidence with this time amount / prediction throttle valve-opening], and sets it to TAest (k-1) whenever [prediction throttle valve-opening]. And only this time to TAest (k-1) and operation period delta Tt search for the pressure-of-induction-pipe force PmTA in the right-hand side with 31 above (=MAPPM (TAest (k-1), NE, VT)) based on the closing motion timing VT and said table MAPPM of a actual inlet valve in front of operation period deltaTt from

the engine speed NE actual [front] and this time whenever [this prediction throttle valve-opening].
[0161] Furthermore, the throttle model M20 calculates the value (PmTA/Pa) which **(ed) said pressure-of-induction-pipe force PmTA by the throttle-valve upstream pressure Pa, and the value phi in the right-hand side with said table MAPphi to 31 above (PmTA/Pa) (=MAPphi (PmTA/Pa)). Similarly, the throttle model M20 calculates the value (Pm (k-1)/Pa) to which the inlet-pipe model M40 mentioned later **(ed) the last pressure-of-induction-pipe force Pm (k-1) already searched for by the throttle-valve upstream pressure Pa, and the value phi in the right-hand side with said table MAPphi to 31 above (Pm/Pa) (=MAPphi (Pm (k-1)/Pa)). By the above, since each factor of the right-hand side with 31 above is called for, the prediction throttle passage air flow rate mts (= mt (k-1)) is calculated by multiplying these.
[0162] (Inlet-valve model M30) The inlet-valve model M30 calculates the intake air flow mc in a cylinder according to several 32 based on the above-mentioned rule of thumb. It asks for a proportionality coefficient c from the actual engine speed NE and the closing motion timing VT and MAPC of a actual inlet valve (NE, VT), and, specifically, the amount d of burned gas is calculated from the actual engine speed NE and the closing motion timing VT and MAPD of a actual inlet valve (NE, VT). Moreover, the inlet-valve model M30 applies the newest pressure-of-induction-pipe force Pm (=Pm (k-1)) already presumed with the inlet-pipe model M40 later mentioned at the operation event, and the newest air temperature Tm (= Tm (k-1)) in an inlet pipe to 32 above, and presumes the intake air flow mc (= mc (k-1)) in a cylinder.
[0163] (Inlet-pipe model M40) The inlet-pipe model M40 calculates the pressure-of-induction-pipe force Pm and the air temperature Tm in an inlet pipe from the air flow rate mc (namely, intake air flow in a cylinder) which flows out of the inlet pipe called for with the throttle passage air flow rate mt, the actual throttle passage air temperature (namely, inhalation air temperature THA) Ta, and the inlet-valve model M30 which were called for with 31 above and 32 above, and the throttle model M20.
[0164] (Inlet-valve model M50) The inlet-valve model M50 The newest pressure-of-induction-pipe force Pm (= Pm (k)) which is the above-mentioned inlet-valve model M30 and the same model, and the inlet-pipe model M40 computed except for the point that the parameters to input differ, and the air temperature Tm (= Tm (k)) in an inlet pipe, The intake air flow mc (= mc (k)) in a cylinder is calculated using several 32 (mc= (THA/Tm) and (c-Pm-d)) based on the above-mentioned rule of thumb. And the inlet-valve model M50 calculates the prediction inhalation air content KLfwd by multiplying the calculated intake air flow mc in a cylinder by the time amount (time amount after an inlet valve 32 opens until it closes the valve) Tint which the intake stroke computed from an engine speed NE takes. The inlet-valve model M50 performs such an operation for every predetermined passage of time for every cylinder.
[0165] Thus, although 2nd air model A4 updates the prediction inhalation air content KLfwd for every predetermined passage of time Based on TAest, the prediction inhalation air content KLfwd is calculated whenever [after the time delay which carries out abbreviation coincidence with the time amount of just before a fuel-injection initiation stage (BTDC90"CA) to the time of inlet-valve clausilium / prediction throttle valve-opening], Based on the prediction inhalation air content KLfwd in the event in front of the fuel-injection initiation period, the fuel oil consumption Fib before amendment is calculated. And this 2nd air model A4 from things Based on TAest, a prediction inhalation air content calculation means to predict an inhalation air content substantially will be constituted whenever [prediction throttle valve-opening / at the time of the inlet-valve clausilium to the intake stroke of a certain cylinder].
[0166] Namely, 2nd inhalation air model A4 is at the 1st predetermined event before A (in this example) at the time of the inlet-valve clausilium to this intake stroke A of a specific cylinder. The predetermined timing before the fuel-injection initiation (BTDC75"CA) to this intake stroke of this cylinder, The prediction inhalation air content KLfwd which is an inhalation air content of A at the time of the inlet-valve clausilium in this intake stroke A of this cylinder in BTDC90"CA specifically The amount of operational status [event / this / which was predicted with the electronics control throttle-valve model M1 which is the amount prediction means of operational status / 1st predetermined] at the event of the point, That is, based on TAest and models M20-M50, it computes whenever [prediction throttle valve-opening / at the event near the A] at the time of the inlet-valve clausilium of this intake stroke A. As mentioned above, the normal fuel oil consumption fi is calculated by each model shown in drawing 5 and drawing 6 , and each means.
[0167] Next, it explains, referring to the flow chart shown in drawing 11 - drawing 18 about actual actuation of an electrical control unit 70.
[0168] (Count of whenever [target throttle valve-opening], and whenever [presumed throttle valve-opening]) CPU71 attains the function of the above-mentioned electronics control throttle-valve logic A1 and the electronics control throttle-valve model M1 by performing the routine shown in drawing 11 with the flow chart for every progress of operation period deltaTt (here 8msec). If it states concretely, CPU71 starts

processing from step 1100 to predetermined timing, and it progresses to step 1105, and "0" will be set as Variable i, and it will progress to step 1110, and will judge whether Variable i is equal to the count ntdly of delay. This count ntdly of delay is the value which **(ed) the time delay TD by operation period deltaTt.
[0169] Since Variable i is "0" at this event, CPU71 is judged at step 1110 to be "No", and while progressing to step 1115 and storing [whenever / provisional target throttle valve-opening] the value of TAt (i+1) in TAt (i) whenever [provisional target throttle valve-opening], the value of TAest (i+1) is stored [whenever / prediction throttle valve-opening] in TAest (i) whenever [prediction throttle valve-opening] at continuing step 1120. By the above processing, the value of TAt (1) is stored [whenever / provisional target throttle valve-opening] in TAt (0) whenever [provisional target throttle valve-opening], and the value of TAest (1) is stored [whenever / prediction throttle valve-opening] in TAest (0) whenever [prediction throttle valve-opening].
[0170] Subsequently, only "1" increases the value of Variable i at step 1125, and CPU71 returns to step 1110. And if the value of Variable i is smaller than this count ntdly of delay, steps 1115-1125 will be performed again. That is, steps 1115-1125 are repeatedly performed until the value of Variable i becomes equal to the count ntdly of delay. Thereby, the sequential shift of the value of TAt (i+1) is carried out [whenever / provisional target throttle valve-opening] whenever [provisional target throttle valve-opening] at TAt (i), whenever [prediction throttle valve-opening], a sequential shift is carried out and the value of TAest (i+1) goes [whenever / prediction throttle valve-opening] to TAest (i).
[0171] Based on the table which judged CPU71 at step 1110 to be "Yes" when the value of Variable i became equal to the count ntdly of delay by repeating the above-mentioned step 1125, progressed to step 1130, and was shown in the accelerator control input Accp actual [of this time], and drawing 7 at this step 1130, TAacc is calculated whenever [this provisional target throttle valve-opening], and this is stored in TAt (ntdly) whenever [provisional target throttle valve-opening].
[0172] Next, CPU71 progresses to step 1135 and computes [whenever / last prediction (presumption) throttle valve-opening / TAest (ntdly) and whenever / this provisional target throttle valve-opening] TAest (ntdly) whenever [this prediction throttle valve-opening] according to TAacc and the formula indicated in step 1135 based on two (right-hand side) above at this step 1135. And while setting [whenever / target throttle valve-opening] the value of TAt (0) as TAt whenever [provisional target throttle valve-opening] at step 1140, TAest (ntdly) is stored [whenever / prediction throttle valve-opening] in TAest whenever [newest prediction throttle valve-opening], it progresses to step 1195, and this routine is once ended.
[0173] As mentioned above, whenever this routine is performed in the memory about TAt, every one content of memory is shifted and it goes, and the value stored in TAt (0) whenever [provisional target throttle valve-opening] is set [whenever / target throttle valve-opening] up as TAt whenever [target throttle valve-opening / which is outputted to throttle-valve actuator 43a by the electronics control throttle-valve logic A1]. That is, the value stored in TAt (ntdly) whenever [provisional target throttle valve-opening] by activation of this routine is stored in TAt (0) when this routine is repeated only for the count ntdly of delay in future, and it serves as TAt whenever [target throttle valve-opening]. Moreover, whenever [prediction throttle valve-opening], in the memory about TAest, TAest is stored in TAest in this memory (m) from this time whenever [after predetermined time (m*delta Tt) progress / prediction throttle valve-opening], and it goes. The value m in this case is the integer of 1 - ntdly.
[0174] (Count of the prediction inhalation air content KLfwd) CPU71 attains the function of 2nd inhalation air model A4 (the throttle model M20, the inlet-valve model M30, the inlet-pipe model M40, and inlet-valve model M50) by performing the prediction inhalation air content count routine shown in drawing 12 for every progress of predetermined operation period deltaTt (8msec). In order for CPU71 to start processing from step 1200, to progress to step 1205 and to calculate the throttle passage air flow rate mt (k-1) with the above-mentioned throttle model M20 (formula shown in step 1205 based on 31 above) when it becomes predetermined timing if it explains concretely, it progresses to step 1300 shown in the flow chart of drawing 13 . In addition, it means that that the variable in the parenthesis of the throttle passage air flow rate mt is k-1 instead of k is the value asked for this throttle passage air flow rate mt (k-1) using the various values in front of operation period deltaTt, and this variable k and the semantics of k-1 are the same about other values described below.
[0175] CPU71 which progressed to step 1300 progresses to step 1305, and asks [this time / the above-mentioned table MAPC and] for the multiplier c with 32 above (=c (k-1)) from the closing motion timing VT of the inlet valve in front of operation period deltaTt from the engine speed NE in front of operation period deltaTt, and this time. Moreover, a value d (=d (k-1)) is similarly calculated [this time / the above-mentioned table MAPD and] from the closing motion timing VT of the inlet valve in front of operation

period deltaTt from the engine speed NE in front of operation period deltaTt, and this time.
[0176] Subsequently, CPU71 progresses to step 1310 and finds the time amount of just before a fuel-injection initiation stage (BTDC90"CA) to the time of inlet-valve clausilium from an engine speed NE. TAest is read from RAM73 whenever [after the time delay which carries out abbreviation coincidence with this time amount / prediction throttle valve-opening]. It is set to TAest (k-1) whenever [prediction throttle valve-opening]. Whenever [prediction throttle valve-opening] TAest (k-1), From the engine speed NE in front of operation period deltaTt, and this time The closing motion timing VT of the inlet valve in front of operation period deltaTt [this time] the above-mentioned table MAPPM -- since -- the pressure-of-induction-pipe force PmTA is searched for, it progresses to step 1315 and the throttle passage air flow rate mtsTA is calculated based on 32 above. In addition, the throttle passage air temperature Ta used in step 1315 uses the inhalation air temperature THA which an inhalation air temperature sensor detects, and the value calculated at step 1215 at the time of this last routine activation mentioned later is used for the air temperature Tm (k-1) in an inlet pipe.
[0177] Subsequently, CPU71 progresses to step 1320 and is calculated from the value (PmTA/Pa) which **(ed) the pressure-of-induction-pipe force PmTA which calculated the value phi (PmTA/Pa) at above-mentioned table MAPphi and the above-mentioned step 1310 by this step 1320 by the throttle-valve upstream pressure (atmospheric pressure which the atmospheric pressure sensor 63 detects) Pa. Moreover, the value which **(ed) the pressure-of-induction-pipe force Pm (k-1) searched for by continuing step 1325 at step 1215 at the time of this last routine activation mentioned later by the throttle-valve upstream pressure Pa (Pm (k-1)/Pa), The value which calculated the value phi (Pm/Pa) and calculated it at the above-mentioned steps 1315 and 1320 and step 1325 from above-mentioned table MAPphi by continuing step 1330, respectively, Based on the formula shown in step 1330 showing a throttle model, the throttle passage air flow rate mt (k-1) is calculated, and it progresses to step 1210 of drawing 12 via step 1395.
[0178] CPU71 calculates the intake air flow mc (k-1) in a cylinder using several 32 which expresses the above-mentioned inlet-valve model M3 with step 1210. At this time, the value calculated at the above-mentioned step 1305 is used as a multiplier c and a value d. Moreover, the inhalation air temperature THA to which an inhalation air temperature sensor detects the throttle passage air temperature Ta is used for the pressure-of-induction-pipe force Pm (k-1) and the air temperature Tm (k-1) in an inlet pipe using the value calculated at step 1215 at the time of this last routine activation mentioned later.
[0179] Next, several 33 which CPU71 progresses to step 1215 and expresses the above-mentioned inlet-pipe model M4 and the equation having shown several 34 to discretized step 1215 (difference equation), It is based on the throttle passage air flow rates mt (k-1) and mc (k-1) calculated at the above-mentioned step 1205 and step 1210, respectively. This pressure-of-induction-pipe force Pm (k) said -- the pressure of induction pipe -- the force -- Pm -- (-- k --) -- this time -- an inlet pipe -- inside -- air temperature -- Tm -- (-- k --) -- having **(ed) -- a value -- {-- Pm/Tm --} -- (-- k --) -- asking . In addition, deltat is time amount expressed with delta t=delta Tt+ (t1-t0), when discrete spacing used with the inlet-pipe model M40 is shown and time amount of the fuel-injection initiation stage of (k) to the time of inlet-valve clausilium is set [computation time] to t1 for the time amount of deltaTt (=8msec) and the last (k-1) fuel-injection initiation stage to the time of inlet-valve clausilium t0 and this time.
[0180] Subsequently, CPU71 progresses to step 1220 and calculates this intake air flow mc in a cylinder (k) based on the formula showing the above-mentioned inlet-valve model M50 shown in this step 1220. If it states concretely, CPU71 will progress to step 1400 shown in drawing 14 , when it progresses to step 1220. It asks for multiplier c (k) at the following step 1405 by the closing motion timing VT and MAPC of an engine speed NE and an inlet valve (c(k) =MAPC (NE, VT)). It asks for value d (k) at continuing step 1410 by the closing motion timing VT and MAPD of an engine speed NE and an inlet valve (d(k) =MAPD (NE, VT)). The engine speed NE at this time and the closing motion timing VT of an inlet valve use the value in this time. And this pressure-of-induction-pipe force Pm that CPU71 progressed to step 1415 and was searched for at the above-mentioned step 1215 (k) And this air temperature Tm in an inlet pipe called for at this step 1215 (k), Using multiplier c (K) called for at step 1405, and value d (k) called for at step 1410, this intake air flow mc in a cylinder (k) is computed, and it progresses to step 1225 of drawing 12 via step 1495.
[0181] It computes the prediction inhalation air content KLfwd by CPU71 calculating the inlet-valve valve-opening time amount (time amount after an inlet valve opens until it closes the valve) Tint from the inlet-valve valve-opening angle determined at step 1225 by the engine speed NE in this time, and the cam profile of an intake cam shaft, and multiplying this above-mentioned intake air flow mc in a cylinder (k) by the inlet-valve valve-opening time amount Tint at continuing step 1230, progresses to step 1295, and once ends this routine. The prediction inhalation air content KLfwd is calculated by the above.

[0182] ((KLact) Real inhalation air content) CPU71 attains the function of 1st inhalation air model A3 (the throttle model M2, the inlet-valve model M3, the inlet-pipe model M4, and inlet-valve model M5) by performing the real inhalation air content count routine shown in drawing 15 for every progress of predetermined operation period deltaTt (8msec). This routine performs the same processing as the prediction inhalation air content count routine of drawing 12 explained previously, and calculates the real inhalation air content KLact. CPU71 performs drawing 16 for performing the respectively same processing as drawing 13 and the routine shown in drawing 14 , and the routine shown in drawing 17 in that case. In addition, in order to distinguish the amount of each, such as a throttle passage air flow rate, from the amount of each of drawing 12 - drawing 14 , the alphabetic character "a" is added to the name tail of ******.
[0183] If the main point of difference between the routine shown in drawing 15 - drawing 17 and the routine shown in drawing 12 R> 2 - drawing 14 is explained briefly, CPU71 will calculate the throttle passage air flow rate mta (k-1) at step 1505 with the above-mentioned throttle model M2 (formula shown in step 1505 based on 31 above).
[0184] At this time, CPU71 performs the routine shown in drawing 16 , and asks [this time / the above-mentioned table MAPC and] for the multiplier c with 32 above (= ca (k-1)) at step 1605 from the closing motion timing VT of the inlet valve in front of operation period deltaTt from the engine speed NE in front of operation period deltaTt, and this time. Moreover, a value d (= da (k-1)) is similarly calculated [this time / the above-mentioned table MAPD and] from the closing motion timing VT of the inlet valve in front of operation period deltaTt from the engine speed NE in front of operation period deltaTt, and this time.
[0185] Subsequently, from the engine speed NE in front of operation period deltaTt, and this time, CPU71 progresses to step 1610, whenever [real throttle valve-opening / which was detected in front of operation period deltaTt from the above-mentioned table MAPPM and this time in the pressure-of-induction-pipe force PmTAa], is calculated from the closing motion timing VT of the inlet valve in front of operation period deltaTt, progresses to step 1615 from TAact (K-1) and this time, and calculates the throttle passage air flow rate mtsTAa based on 32 above. In addition, the throttle passage air temperature Ta used in step 1615 uses the inhalation air temperature THA which an inhalation air temperature sensor detects, and the value calculated at step 1515 at the time of this last routine activation mentioned later is used for the air temperature Tma (k-1) in an inlet pipe.
[0186] Subsequently, CPU71 is calculated from the value (PmTAa/Pa) and above-mentioned MAPphi to which it progressed to step 1620, and the value phi (PmTAa/Pa) was **(ed) at this step 1620, and it **(ed) the above-mentioned pressure-of-induction-pipe force PmTAa by the throttle-valve upstream pressure Pa. Moreover, the value which **(ed) the pressure-of-induction-pipe force Pma (k-1) searched for by continuing step 1625 at step 1515 at the time of this last routine activation mentioned later by the throttle-valve upstream pressure Pa (Pma (k-1)/Pa), The value which calculated the value phi (Pma/Pa) and calculated it at the above-mentioned steps 1615 and 1620 and step 1625 from above-mentioned table MAPphi by continuing step 1630, respectively, Based on the formula shown in step 1630 showing a throttle model, the throttle passage air flow rate mta (k-1) is calculated, and it progresses to step 1510 of drawing 15 via step 1695.
[0187] CPU71 calculates the intake air flow mca (k-1) in a cylinder using several 32 which expresses the above-mentioned inlet-valve model M30 with step 1510. At this time, the value calculated at the above-mentioned step 1605 is used as a multiplier ca and a value da. Moreover, the pressure-of-induction-pipe force Pma (k-1) and the air temperature Tma (k-1) in an inlet pipe use the inhalation air temperature THA to which an inhalation air temperature sensor detects the throttle passage air temperature Ta using the value calculated at step 1515 at the time of this last routine activation mentioned later.
[0188] next -- CPU -- 71 -- a step -- 1515 -- progressing -- a throttle -- passage -- an air flow rate -- mta (k-1) -- and -- a cylinder -- inside -- an intake air flow -- mca (k-1) -- being based -- this time -- the pressure of induction pipe -- the force -- Pma -- (-- k --) -- said -- the pressure of induction pipe -- the force -- Pma -- (-- k --) -- this time -- an inlet pipe -- inside -- air temperature -- Tma -- (-- k --) -- having **(ed) -- a value -- {-- Pma/Tma --} -- (-- k --) -- asking . Subsequently, CPU71 progresses to step 1520 and calculates this intake air flow mca in a cylinder (k) based on the formula showing the above-mentioned inlet-valve model M50 shown in this step 1520. In this case, CPU71 asks for a multiplier ca (k) at step 1705 shown in drawing 17 by the closing motion timing VT and MAPC of an engine speed NE and an inlet valve (ca(k) =MAPC (NE, VT)), and calculates a value da (k) at continuing step 1610 by the closing motion timing VT and MAPD of an engine speed NE and an inlet valve (deca(k) =MAPD (NE, VT)). The engine speed NE used here and the closing motion timing VT of an inlet valve use the value in this time. And CPU71 progresses to step 1715, using this pressure-of-induction-pipe force Pma (k), this air temperature Tma in an inlet pipe (k), a

multiplier ca (K), and a value da (k), computes this intake air flow mca in a cylinder (k), and progresses to step 1525 of drawing 15 via step 1795.
[0189] It computes the real inhalation air content KLact by CPU71 calculating the inlet-valve valve-opening time amount Tint from the inlet-valve valve-opening angle determined at step 1525 by the engine speed NE in this time, and the cam profile of an intake cam shaft, and multiplying this above-mentioned intake air flow mca in a cylinder (k) by the inlet-valve valve-opening time amount Tint at continuing step 1530. Subsequently, it progresses to step 1535, and if an inlet valve judges whether it is immediately after changing from a valve-opening condition to a clausilium condition and is immediately after, it stores the real inhalation air content KLact at step 1540 as a real inhalation air content KLact0 at the time of inlet-valve clausilium, and it progresses to step 1595, and, as for CPU71, this time once ends this routine. Moreover, when judged with "No" at step 1535, CPU71 progresses to the direct step 1595, and once ends this routine. By the above, the real inhalation air content KLact0 at the time of inlet-valve clausilium is calculated based on TAact whenever [real throttle valve-opening]. In addition, the real inhalation air content KLact0 is calculated for every cylinder, and is stored in RAM73 in the condition of having been matched with each cylinder.
[0190] (Injection running routine) Next, if an electrical control unit 70 explains this routine about the routine performed in order to inject actually with reference to drawing 18 shown with the flow chart, CPU71 will perform the routine shown in this drawing 18 for every cylinder, whenever whenever [crank angle / of each cylinder] is set to BTDC90"CA.
[0191] Therefore, if whenever [crank angle / of a specific cylinder (arbitration)] is set to BTDC90"CA, CPU71 will calculate the prediction (Fcfwd=KLfwd/AbyFref) need fuel quantity Fcfwd by starting processing from step 1800 and **(ing) the prediction inhalation air content KLfwd with the target air-fuel ratio AbyFref at continuing step 1805. CPU71 at step 1810 whenever [prediction throttle valve-opening / at the time of inlet-valve close / in this intake stroke of this specific cylinder] Subsequently, TAest, It is based on the actual engine speed NE and the closing motion timing VT of a actual inlet valve. The fuel deposit efficiency Rpi to an inlet port, While asking for the fuel deposit efficiency Rvi to an inlet valve, the fuel residual percentage Ppi to an inlet port, and the fuel residual percentage Pvi to an inlet valve, according to the reverse model of the fuel behavior expressed with the right-hand side with four above (formula indicated in step 1810), the fuel oil consumption Fib before amendment (k) is calculated.
[0192] Next, it is assumed that CPU71 injects the fuel oil consumption Fib before amendment (k) which progressed to step 1815 and was calculated at said step 1810 from this intake stroke of a specific cylinder to this specific cylinder. The prediction port fuel coating weight fwpi which is after the intake stroke of this this time, and is predicted to have adhered to the inlet port of this cylinder just before a next intake stroke (k+1) And the prediction bulb fuel coating weight fwvi (k+1) which is after the intake stroke of this time of this cylinder, and is predicted to have adhered to the inlet valve of this cylinder just before a next intake stroke is calculated based on five above and six (formula indicated in step 1815) above.
[0193] Subsequently, CPU71 progresses to step 1820 and reads the real inhalation air content KLact0 at the time of the inlet-valve clausilium in the last intake stroke of said specific cylinder from RAM73 at this step 1820. By what (KLact0/AbyFref) this fruit inhalation air content KLact0 is **(ed) for with the target air-fuel ratio AbyFref asked by target air-fuel ratio setting-out means A5 The real need fuel quantity Fcact which is the fuel quantity which was required in order to make an air-fuel ratio into the target air-fuel ratio AbyFref in the last intake stroke of this specific cylinder is calculated.
[0194] Next, CPU71 follows a formula similar to five above indicated in this step at step 1825, and six above. The fuel oil consumption fi (k-1) actually injected to the last intake stroke (intake stroke of the arbitration of a specific cylinder), The actual port [are after the intake stroke (intake stroke 1 time before the intake stroke of this arbitration) of the second from last time of this cylinder, and] fuel coating weight fwp (k-1) in front of the last intake stroke (before the intake stroke of this arbitration) (real port fuel coating weight), And it is based on the actual bulb fuel coating weight (real bulb fuel coating weight) fwv (k-1). The real port fuel coating weight fwp (k) in front of this intake stroke (the next intake stroke of the intake stroke of this arbitration (1-time back)) and the real bulb fuel coating weight fwv (k) are computed by being after the intake stroke (intake stroke of this arbitration) of the last time of this cylinder.
[0195] Next, CPU71 progresses to step 1830 and computes the real inhalation fuel quantity Fcest in the last intake stroke of a specific cylinder based on the formula indicated in this step. In addition, he is trying to calculate the real inhalation fuel quantity Fcest at step 1830 by reducing the increment of each fuel coating weight from the normal fuel oil consumption fi (k-1). CPU71 subsequently, by progressing to step 1835 and reducing the real inhalation fuel quantity Fcest from the real need fuel quantity Fcact to the last intake stroke

the inhalation fuel quantity error Fcerr in a cylinder showing a part for the excess and deficiency of the fuel quantity in the last intake stroke (k) -- asking (ten above -- reference --) Based on the formula indicated in this step, the amount Ffb of fuel feedback amendments (k) is calculated at continuing step 1840 (see 11 above). In addition, in the formula indicated in this step, SumFcerr is the integral value of the inhalation fuel quantity error Fcerr searched for based on 12 above, and is computed at step 1855 mentioned later. A multiplier Kp and a multiplier Ki are the proportionality constant set up beforehand, respectively and an integration constant. That is, step 1855 constitutes some feedback controllers (proportion and integral control machine) for calculating the amount Ffb of fuel feedback amendments.
[0196] CPU71 progresses to step 1845 and subsequently, the fuel oil consumption (normal fuel oil consumption) (k) fi of the normal to this intake stroke The fuel oil consumption Fib before amendment (k) calculated at said step 1810 is amended and calculated in the amount Ffb of fuel feedback amendments (k) calculated at step 1840 (applying the amount Ffb of fuel feedback amendments (k) to the fuel oil consumption Fib before amendment (k)). Injection of the fuel of the normal fuel oil consumption fi (k) is directed to the injector of said specific cylinder at continuing step 1850. Thereby, the fuel of an amount according to the normal fuel oil consumption fi (k) is injected from the injector 39 of said specific cylinder. Then, CPU71 progresses to step 1855, for the operation of this next routine, it integrates with the inhalation fuel quantity error Fcerr, updates the error integral value SumFcerr, and once ends this routine at step 1895.
[0197] As mentioned above, according to the 1st fuel-oil-consumption control unit, as explained, the last real need fuel quantity and the real inhalation fuel quantity to an intake stroke are calculated, the excess and deficiency of fuel quantity to the intake stroke of this **** are computed based on these differences, and a part for this excess and deficiency is reflected in the fuel oil consumption on and after this time, is compensated, and goes. consequently -- since the excess and deficiency of supply fuel quantity based on differing from whenever [throttle valve-opening / with the actual amount of prediction operational status by the amount prediction means of operational status (whenever / prediction throttle valve-opening /, therefore, prediction inhalation air content)] (therefore, actual inhalation air content) are compensated promptly -- an air-fuel ratio -- abbreviation -- it may be maintained uniformly.
[0198] Next, the operation gestalt (the 2nd fuel-oil-consumption control unit) of the fuel-oil-consumption control unit concerning the 2nd operation gestalt of this invention is explained. Only the functions in which this 2nd fuel-oil-consumption control unit is attained by CPU71 to the 1st fuel-oil-consumption control unit differ. Therefore, only the point of difference in a function is explained below.
[0199] The 2nd fuel-oil-consumption control unit which showed the functional block diagram to drawing 19 The 1st fuel-oil-consumption control unit has. The amount acquisition means A2 of operational status, 1st inhalation air model A3, the order model A54 of fuel behavior, the electronics control throttle-valve model M1, 2nd inhalation air model A4, target air-fuel ratio setting-out means A5, the prediction need fuel quantity calculation means A51, and the fuel-oil-consumption calculation means A52 before amendment (fuel behavior reverse model) While having, it has the amount calculation means A61 of fuel feedback amendments replaced with the amount calculation means A55 of fuel feedback amendments of this 1st fuel-oil-consumption control device, and the fuel-oil-consumption calculation means A62. Since the model with which the 1st fuel-oil-consumption control device is equipped, the same model as a means, and a means attain the same function, they omit detailed explanation. In addition, although the graphic display is omitted in drawing 19 , whenever [throttle valve-opening / of the internal combustion engine with which the 2nd fuel-oil-consumption control unit is applied] is controlled by the electronics control throttle-valve logic A1 with which the 1st fuel-oil-consumption control unit is equipped based on TAt whenever [target throttle valve-opening / by which only the time delay TD was delayed to the accelerator control input Accp].
[0200] The electronics control throttle-valve model M1 is the same model as the electronics control throttle-valve model M1 of the 1st fuel-oil-consumption control device, and constitutes an amount prediction means of operational status (TAest is calculated whenever [prediction throttle valve-opening]) to predict whenever [throttle valve-opening / which is the amount of operational status of said internal combustion engine at the event of the point] from this time. Moreover, the amount acquisition means A2 of operational status acquires TA whenever [throttle valve-opening / which is the actual amount of operational status of said internal combustion engine at the event before this time].
[0201] 2nd inhalation air model A4 is the same model as 2nd inhalation air model A4 of the 1st fuel-oil-consumption control device. The prediction inhalation air content KLfwd which is an inhalation air content at the time of the inlet-valve clausilium in this intake stroke of this cylinder at the 1st predetermined event before the time of the inlet-valve clausilium to this intake stroke of a specific cylinder with said amount prediction means of operational status A prediction inhalation air content calculation means to compute

based on TAest and the air model which modeled the behavior of the air in said internal combustion engine's inhalation-of-air system whenever [throttle valve-opening / which is the amount of operational status at the event of the point] from this predicted 1st predetermined event is constituted.
[0202] The fuel-oil-consumption calculation means A52 before amendment is the same as that of the fuel-oil-consumption control means A52 before amendment of the 1st fuel-oil-consumption control unit. The prediction need fuel quantity Fcfwd which it is at the event after said 1st predetermined event, and is the fuel quantity needed for this cylinder by this intake stroke of said cylinder based on said prediction inhalation air content KLfwd at the 2nd predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The fuel deposit efficiency Rp and Rv of the reverse model of a fuel behavior model which expresses the fuel adhesion behavior to said internal combustion engine's inhalation-of-air system while computing, The fuel residual percentage Pp and Pv And the prediction inhalation air content KLfwd at the time of inlet-valve close [said] It is alike, and it is based on a actual engine speed and the actual inlet-valve closing motion timing VT, it is decided that it will be them, and the reverse model of the fuel behavior model of this determined deposit efficiency Rp and Rv and residual percentage Pp and Pv is used. It is a means to compute the fuel oil consumption Fib before amendment (k) which is temporary injection quantity which should be injected to this intake stroke of this cylinder.
[0203] More specifically the fuel-oil-consumption calculation means A52 before amendment It sets to this intake stroke of this cylinder among the fuels of the fuel oil consumption Fib before amendment (k). The sum with the fuel quantity inhaled by this cylinder in this intake stroke of this cylinder among the fuels of the prediction fuel coating weight fwi (k) which is after the intake stroke of the last time of the fuel quantity inhaled by this cylinder and this cylinder, and is the predicted fuel coating weight in front of this intake stroke the fuel oil consumption Fib before the said amendment (k) is computed so that it may become equal to said computed prediction need fuel quantity Fcfwd (namely, four above -- following).
[0204] The fuel-oil-consumption calculation means A52 before amendment moreover, at the 3rd predetermined event before said 2nd predetermined event While determining the deposit efficiency Rp and Rv used for said fuel behavior model based on the prediction inhalation air content KLfwd used as the foundation which computes the fuel oil consumption before amendment to the last intake stroke of said cylinder, and residual percentage Pp and Pv The fuel behavior model of this deposit efficiency Rp and Rv and residual percentage Pp and Pv, and the prediction [are after the intake stroke of the second from last time of this cylinder, and] fuel coating weight before the last intake stroke, Based on the fuel oil consumption before amendment to the last intake stroke of this cylinder, a prediction fuel coating weight calculation means to compute said prediction fuel coating weight fwi in front of this intake stroke (k) by being after the intake stroke of the last time of this cylinder is included.
[0205] On the other hand, 1st inhalation air model A3 is the same as that of 1st inhalation air model A3 of the 1st fuel-oil-consumption control device. Are at the event after the time of the inlet-valve clausilium to the last intake stroke of said cylinder, and at the 4th predetermined event before the time of the inlet-valve clausilium to this intake stroke of this cylinder The real inhalation air content KLact which is a actual inhalation air content at the time of the inlet-valve clausilium to the last intake stroke of this cylinder with said operational status acquisition means A2 A real inhalation air content calculation means to compute based on TAact and said air model whenever [real throttle valve-opening / which is the acquired actual amount of operational status] is constituted.
[0206] The order model A54 of fuel behavior is the same model as the order model A54 of fuel behavior of the 1st fuel-oil-consumption control device. Are at the event after said 4th predetermined event, and at the 5th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder While determining the multiplier (deposit efficiency, residual percentage) of said fuel behavior model based on the real inhalation air content KLact at the time of the inlet-valve clausilium to the last intake stroke of this cylinder The fuel behavior model of this deposit efficiency and residual percentage, and the fuel oil consumption fi (k-1) actually injected to the last intake stroke of this cylinder, It is based on the real fuel coating weight fw (k-1) which is after the intake stroke of the second from last time of this cylinder, and is the actual fuel coating weight in front of the last intake stroke. A real fuel coating weight calculation means to compute the real fuel coating weight fw in front of this intake stroke (k) by being after the intake stroke of the last time of this cylinder is constituted.
[0207] The amount calculation means A61 of fuel feedback amendments Are at the event after said said 3rd predetermined and 5th predetermined event, and at the 6th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The prediction [are after the intake stroke of the last time of this cylinder computed by said prediction fuel coating weight calculation means, and] fuel coating

weight fwi before this intake stroke (k), Based on the fuel coating weight error Fwerr (k) which is after the intake stroke of the last time of this cylinder computed by said real fuel coating weight calculation means, and is a difference with the real fuel coating weight fw in front of this intake stroke (k), the amount Ffb of fuel feedback amendments (k) is computed.

[0208] When it states more concretely, the amount calculation means A61 of fuel feedback amendments Prediction [are after the intake stroke of the last time of the specific cylinder which the fuel-oil-consumption calculation means A52 before amendment computed, and] fuel coating weight fwi before this intake stroke (k) (it is the sum of the prediction port fuel coating weight fwpi (k) and the prediction bulb fuel coating weight fwvi (k) in this case.) Actual fuel [are after the intake stroke of the last time of this specific cylinder which the order model A54 of fuel behavior computed, and] coating weight fw in front of this intake stroke (k) (it is the sum of the real port fuel coating weight fwp (k) and the real bulb fuel coating weight fwv (k) in this case.) A difference is searched for as a fuel coating weight error Fwerr (k).

[0209] Namely, the fuel oil consumption Fib before amendment asked for the prediction fuel coating weight fwi (k) based on TAest (therefore, the prediction inhalation air content KLfwd) whenever [prediction throttle valve-opening / at the time of the inlet-valve clausilium to the last intake stroke], The fuel residual percentage Ppi and Pvi called for based on this prediction inhalation air content KLfwd, Since it is the value computed by the fuel deposit efficiency Rpi and Rvi, it is a value including the prediction error of the inhalation air content at the time of the inlet-valve clausilium to the last intake stroke. And the real fuel coating weight fw (k) The fuel residual percentage Pp and Pv based on the actual normal fuel oil consumption fi (k) and the real inhalation air content KLact calculated according to TAact whenever [actual throttle valve-opening / at the time of this inlet-valve clausilium], And since it is the value computed by the fuel deposit efficiency Rp and Rv, it is the value which does not include the prediction error of an inhalation air content. Therefore, the fuel coating weight error Fwerr (k) which are these differences serves as a value reflecting the presumed error of the prediction inhalation air content over a actual inhalation air content.

[0210] The amount calculation means A61 of fuel feedback amendments calculates the amount Ffb of fuel feedback amendments (k) based on this coating weight error fwerr (k). In this case, it is the same PI controller (proportion and an integral-control machine) as the above-mentioned amount calculation means A55 of fuel feedback amendments, and, as for the amount calculation means of fuel feedback amendments, the amount Ffb of fuel feedback amendments (k) calculates according to the formula which permuted the inhalation fuel-quantity error Fcerr by the fuel coating-weight error Fwerr, and permuted an inhalation fuel-quantity error integral value SumFcerr by the fuel coating-weight error integral value SumFwerr in ten above - 12 above, respectively.

[0211] Are the normal fuel-oil-consumption calculation means A62 at the event after said said 2nd predetermined and 6th predetermined event, and at the 7th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder The fuel oil consumption Fib before the said amendment (k) is amended by applying said computed amount Ffb of fuel feedback amendments (k) to the fuel oil consumption Fib before amendment (k) which should be injected to this intake stroke of said this computed cylinder. The normal fuel oil consumption fi (k) which this injects to this intake stroke of said cylinder is computed.

[0212] It is the fuel-injection directions means which is not illustrated at the event after said 7th predetermined event, and it gives directions to drawing 19 so that the fuel of said computed normal fuel oil consumption fi (k) may be injected to the injector 39 which is said fuel-injection means at the 8th predetermined event before the time of the inlet-valve clausilium to this intake stroke of said cylinder. Consequently, the fuel of the normal fuel oil consumption fi (k) is injected to this intake stroke of said cylinder.

[0213] Thus, the 2nd fuel-oil-consumption control unit amends the fuel oil consumption before amendment based on the difference of actual fuel coating weight and prediction fuel coating weight based on knowledge that the prediction error of an inhalation air content appears as a presumed error of prediction fuel coating weight. Therefore, an air-fuel ratio is maintained uniformly.

[0214] Next, the modification of the 2nd fuel-oil-consumption control unit is explained. This modification is equipped with the amount calculation means A71 of fuel behavior-model amendments replaced with the amount calculation means A61 of fuel feedback amendments of the above-mentioned 2nd fuel-oil-consumption control device as shown in drawing 20 . With the amount calculation means A71 of said fuel behavior-model amendments, the fuel deposit efficiency Rvi and Rpi and fuel residual percentage Pvi of the fuel behavior reverse model A52, Only in the point which amends Ppi, and the point that the injection quantity which the fuel behavior reverse model A52 computes turns into the normal fuel oil consumption fi

(k) promptly, it differs from this 2nd fuel-oil-consumption control unit.
[0215] If it is in the modification shown in drawing 20 , namely, the amount calculation means A71 of fuel behavior-model amendments Prediction [are after the intake stroke of the last time of the specific cylinder which the fuel behavior reverse model A52 computed, and] fuel coating weight fwi before this intake stroke (k) (it is the sum of the prediction port fuel coating weight fwpi (k) and the prediction bulb fuel coating weight fwvi (k) in this case.) Actual fuel [are after the intake stroke of the last time of this specific cylinder which the order model A54 of fuel behavior computed, and] coating weight fw in front of this intake stroke (k) (in this case) it is the sum of the real port fuel coating weight fwp (k) and the real bulb fuel coating weight fwv (k). Based on the fuel coating weight error Fwerr (k) which is a difference, the fuel deposit efficiency Rvi and Rpi and the fuel residual percentage Pvi and Ppi of this fuel behavior reverse model A52 are amended.
[0216] More specifically the amount calculation means A71 of fuel behavior-model amendments If the fuel coating weight error Fwerr (k) is a forward value, the fuel deposit efficiency Rvi and Rpi, And the amounts delta R and delta P of amendments for reducing the fuel residual percentage Pvi and Ppi, respectively It asks according to the magnitude of this fuel coating weight error Fwerr (k), and only delta R and delta P carry out reduction amendment of the fuel deposit efficiency Rvi and Rpi which the fuel behavior reverse model A52 uses by this, and the fuel residual percentage Pvi and Ppi, respectively. If the fuel coating weight error Fwerr (k) is a negative value, similarly The fuel deposit efficiency Rvi and Rpi, And the amounts delta R and delta P of amendments for increasing the fuel residual percentage Pvi and Ppi, respectively It asks according to the magnitude of the absolute value of this fuel coating weight error Fwerr (k), and only delta R and delta P carry out buildup amendment of the fuel deposit efficiency Rvi and Rpi which the fuel behavior reverse model A52 uses by this, and the fuel residual percentage Pvi and Ppi, respectively. Consequently, since sequential amendment of the prediction fuel coating weight fwi is carried out, the normal fuel oil consumption fi (k) is amended, and an air-fuel ratio is maintained uniformly.
[0217] As explained above, since it is accurate, and it is compensated promptly and it goes based on the amount of operational status with the amount of [of the fuel resulting from the prediction error of the amount of operational status] actual excess and deficiency, according to each operation gestalt of the fuel-oil-consumption control unit of the internal combustion engine by this invention, an air-fuel ratio is maintainable to a target air-fuel ratio with a sufficient precision.
[0218] In addition, this invention is not limited to the above-mentioned operation gestalt, and can adopt various modifications within the limits of this invention. For example, as shown in drawing 21 , a fuel-oil-consumption control unit can also consist of modes which combined the modification of the 1st fuel-oil-consumption control unit and the 2nd fuel-oil-consumption control unit. Moreover, in each above-mentioned operation gestalt, when an internal combustion engine is in a steady operation condition, it is suitable to be constituted so that the inhalation air content in this intake stroke may be substantially based on the output of an air flow meter 61 and may be determined as it.

[Translation done.]

* NOTICES *

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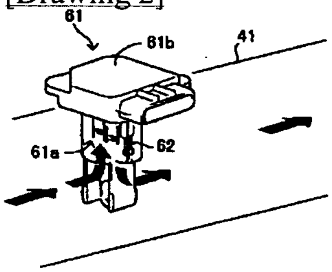
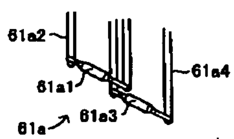
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

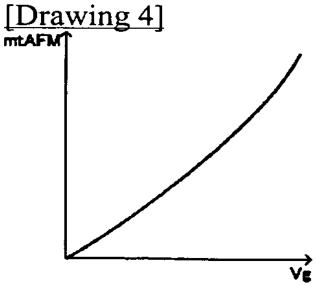
[Drawing 2]



[Drawing 3]



[Drawing 4]



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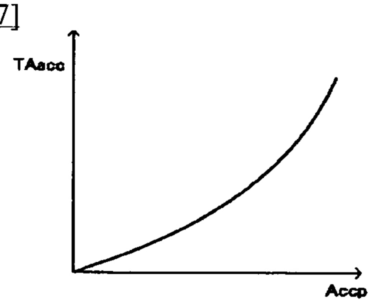
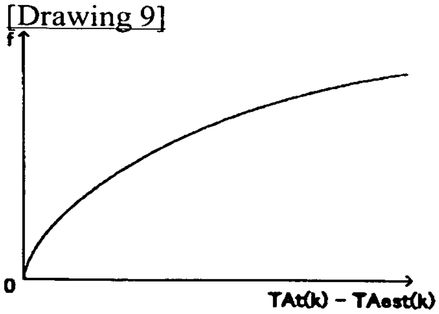


[Drawing 9]



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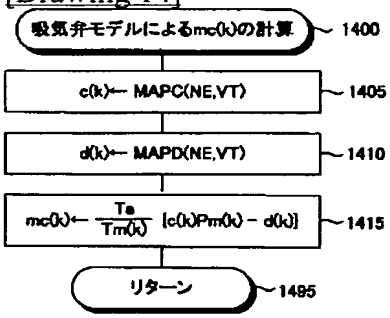

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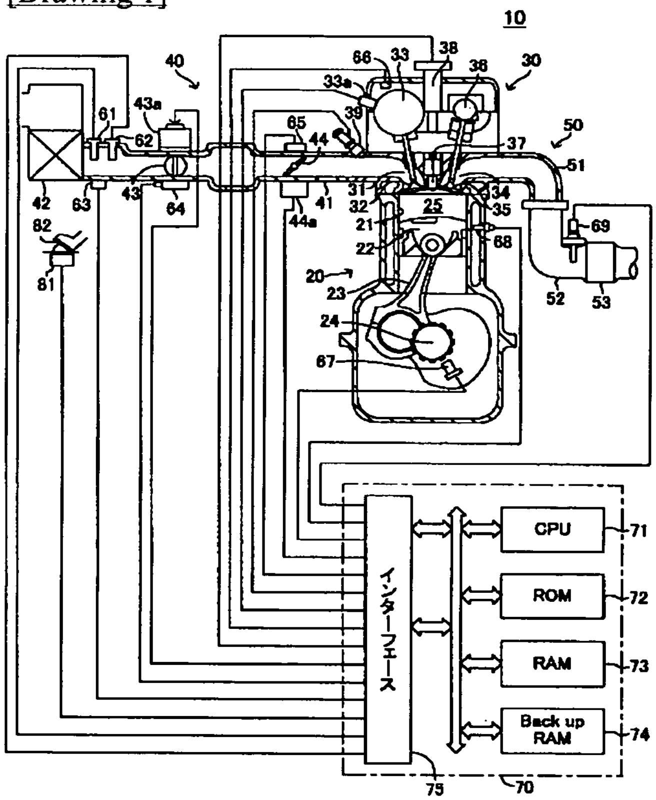
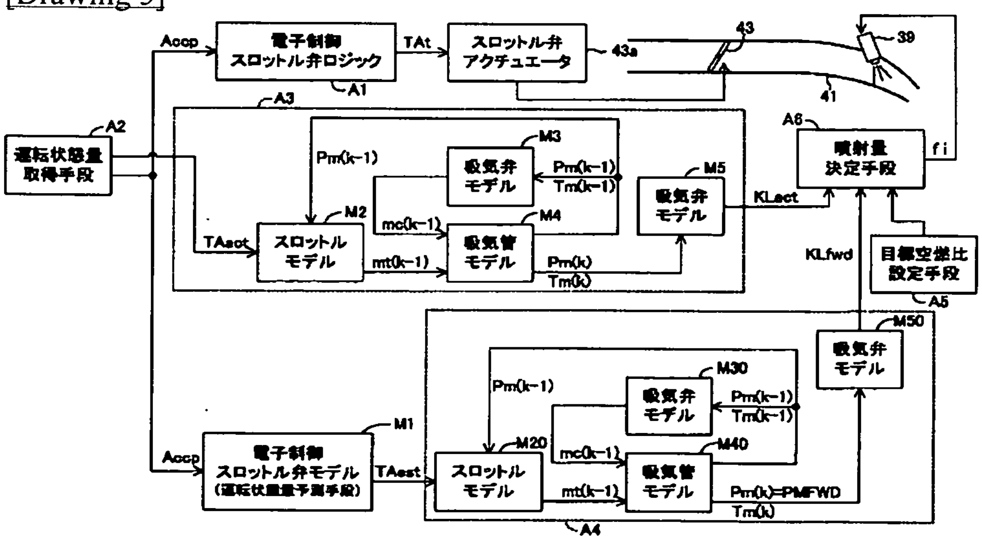
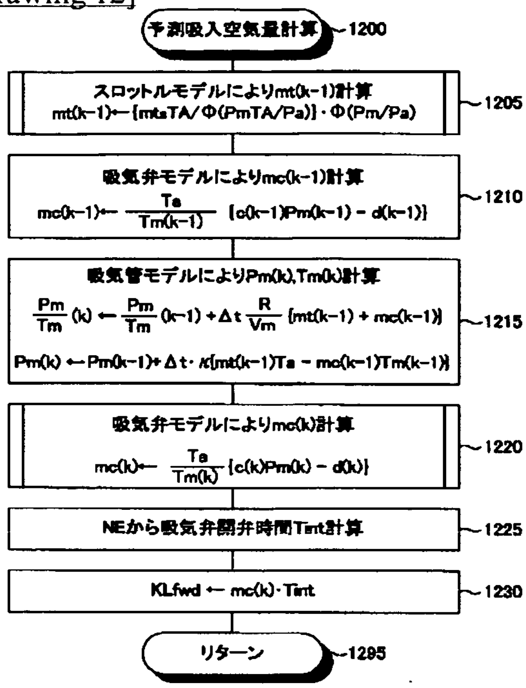


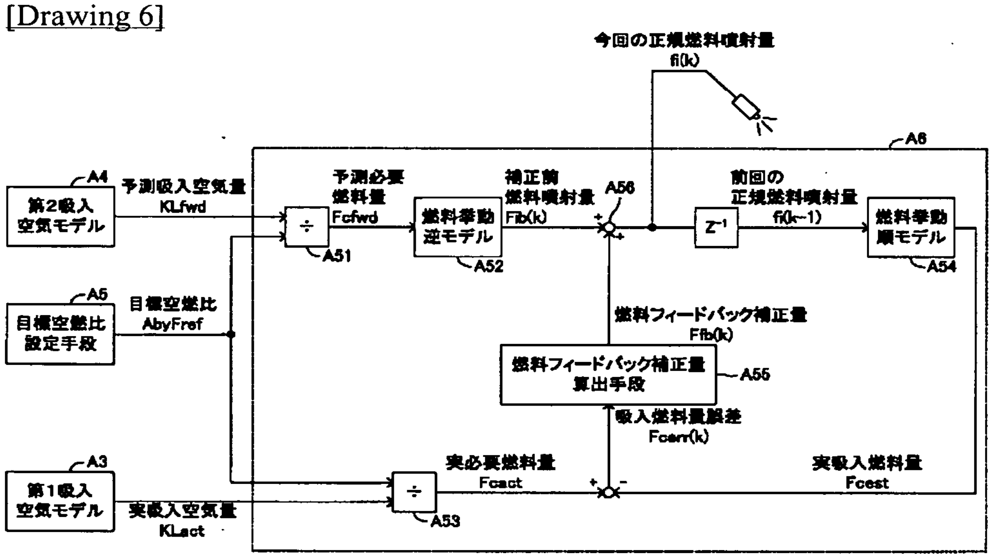
[Drawing 5]



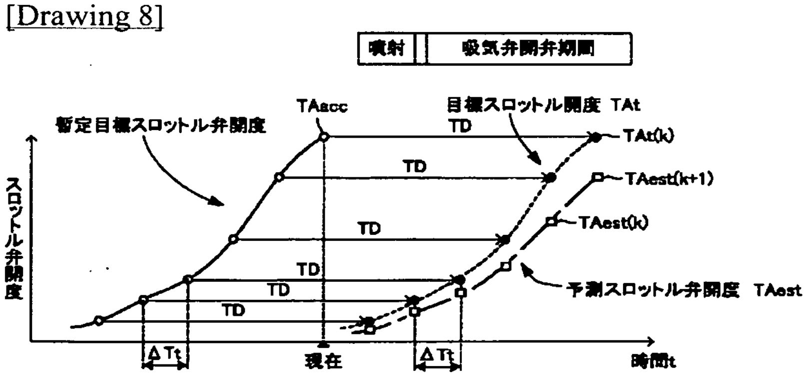
[Drawing 12]



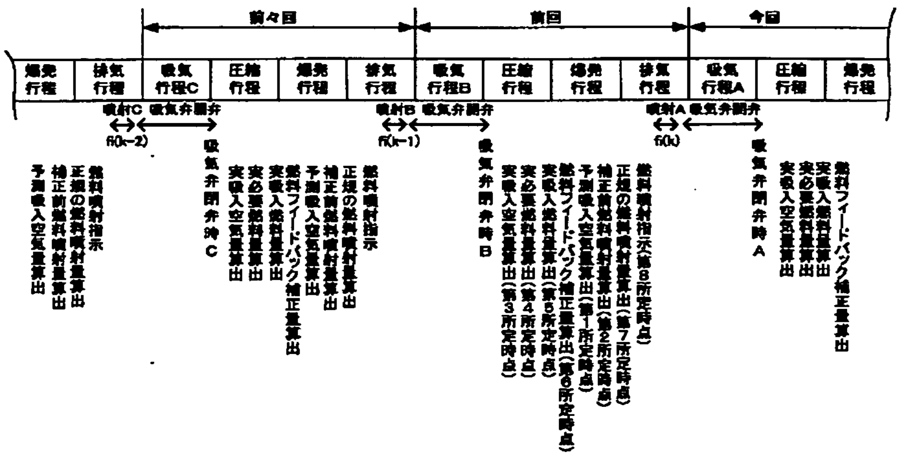
[Drawing 6]



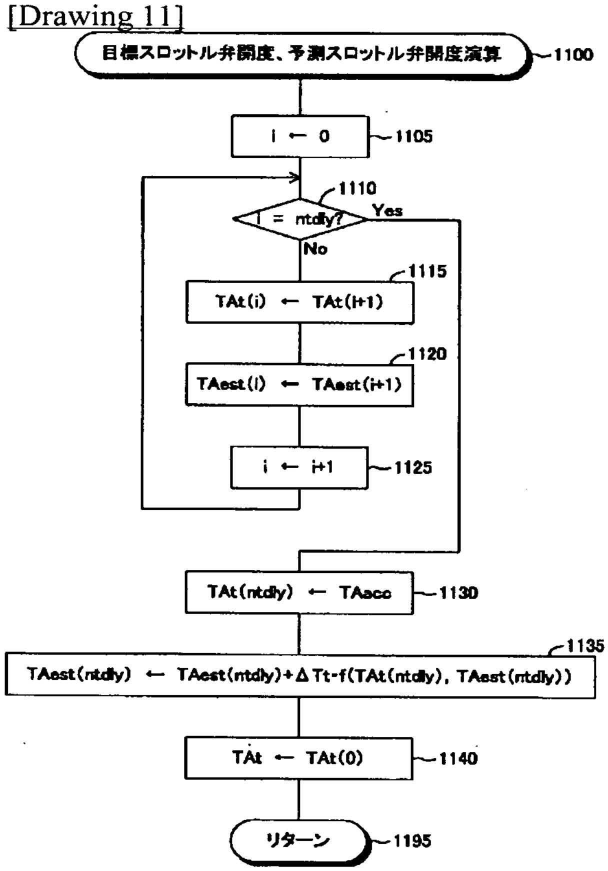
[Drawing 8]



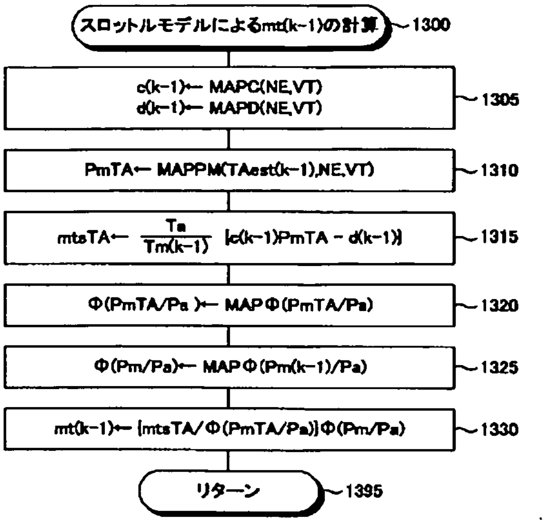
[Drawing 10]



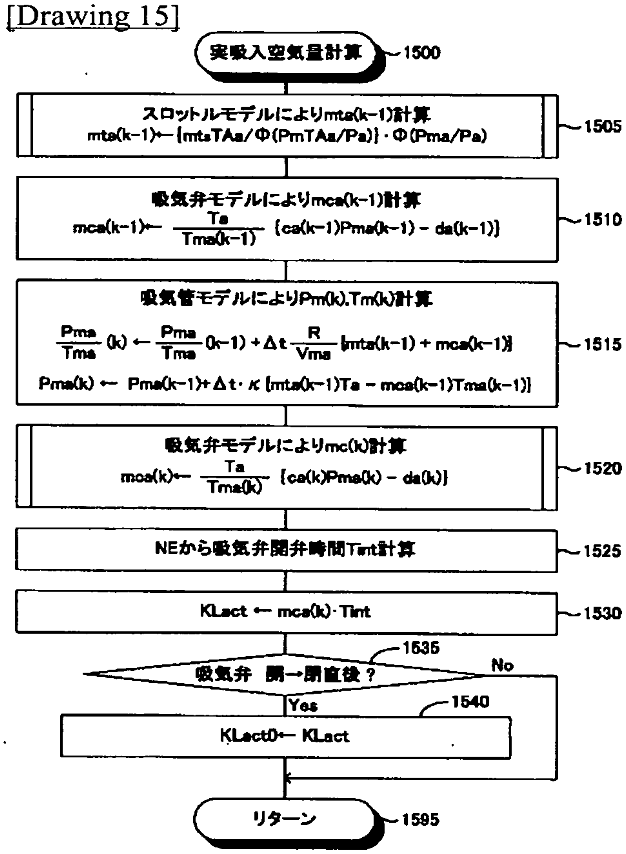
[Drawing 11]



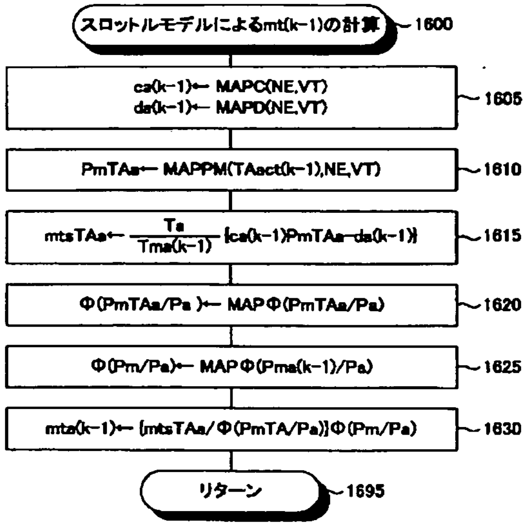
[Drawing 13]



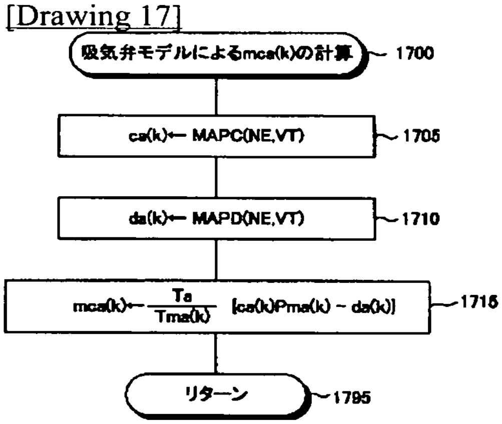
[Drawing 15]



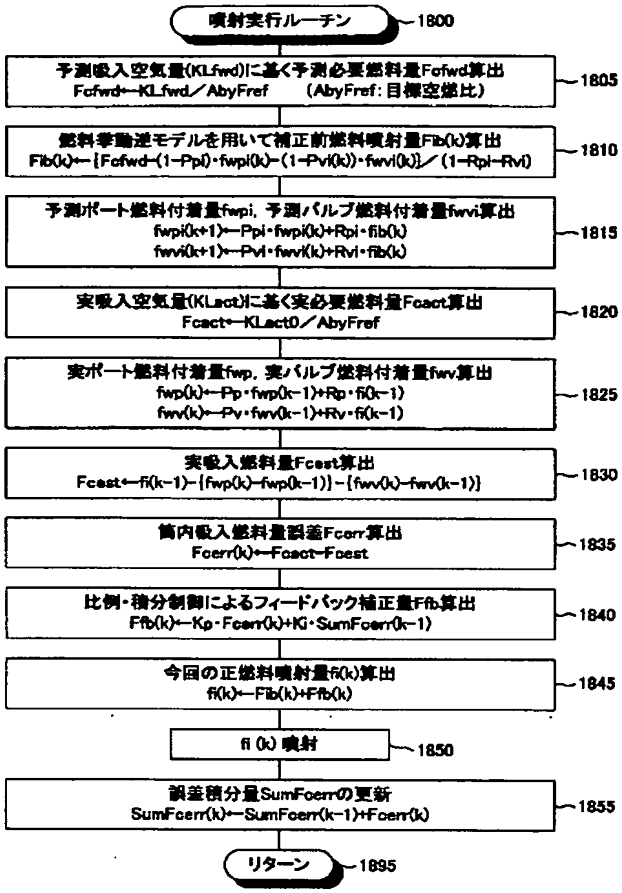
[Drawing 16]



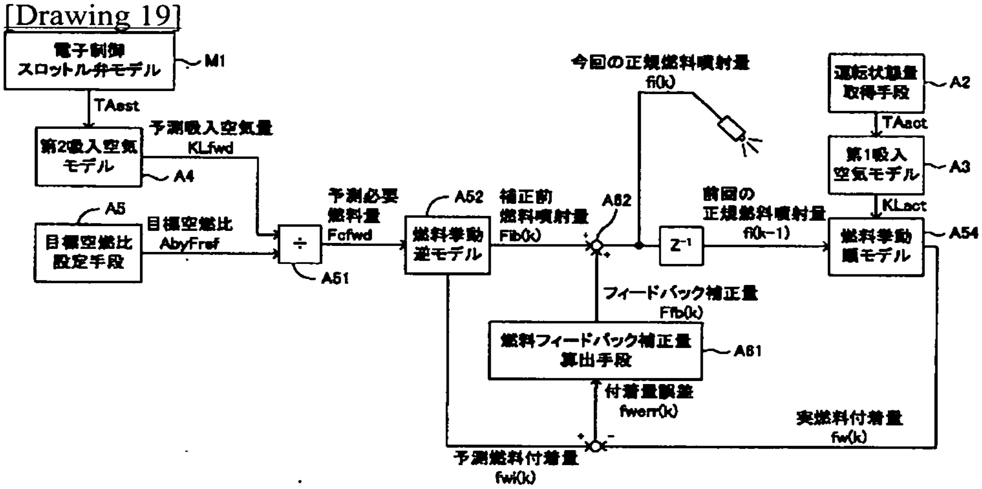
[Drawing 17]



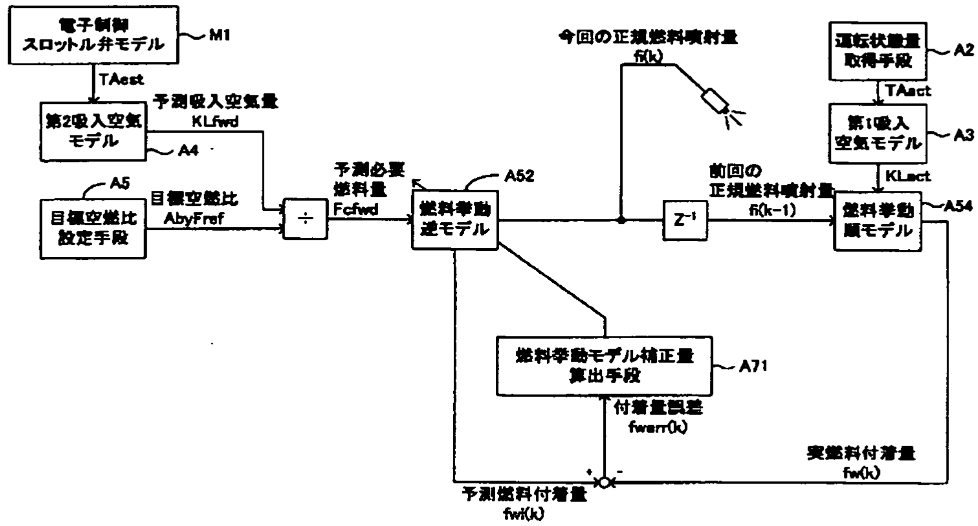
[Drawing 18]



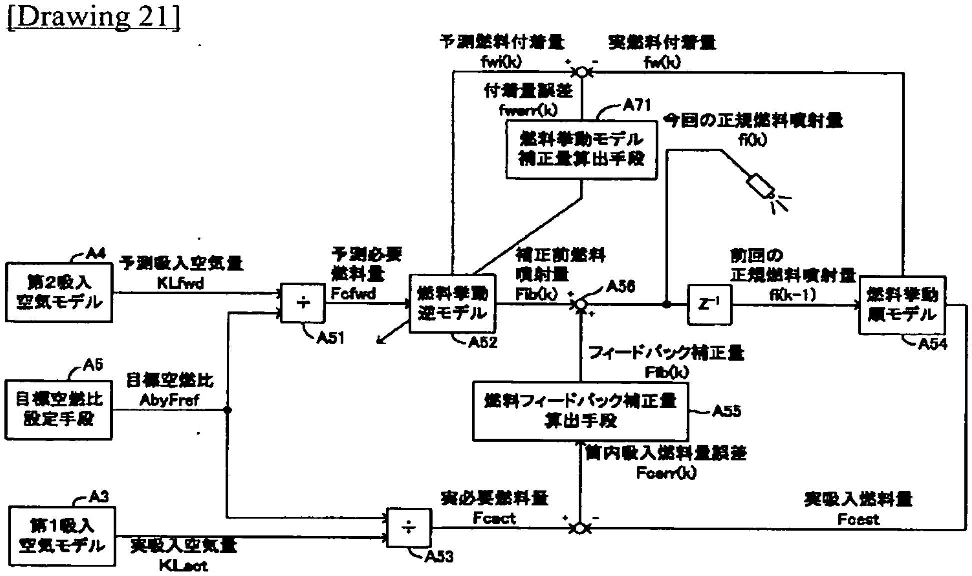
[Drawing 19]



[Drawing 20]



[Drawing 21]



[Translation done.]

(19)日本国特許庁（ＪＰ）

(12) **公開特許公報**（Ａ）

(11)特許出願公開番号

特開2003－184613

（P2003－184613A）

(43)公開日　平成15年7月3日(2003.7.3)

(51)Int.Cl.⁷		識別記号	ＦＩ			テーマコード゛(参考)
Ｆ０２Ｄ	41/14	３３０	Ｆ０２Ｄ	41/14	３３０Ａ	３Ｇ０８４
	41/04	３３０		41/04	３３０Ｂ	３Ｇ３０１
	45/00	３６４		45/00	３６４Ｎ	
		３６６			３６６Ｅ	

審査請求　未請求　請求項の数４　ＯＬ　（全 30 頁）

(21)出願番号　特願2001－386198(P2001－386198)

(22)出願日　平成13年12月19日(2001.12.19)

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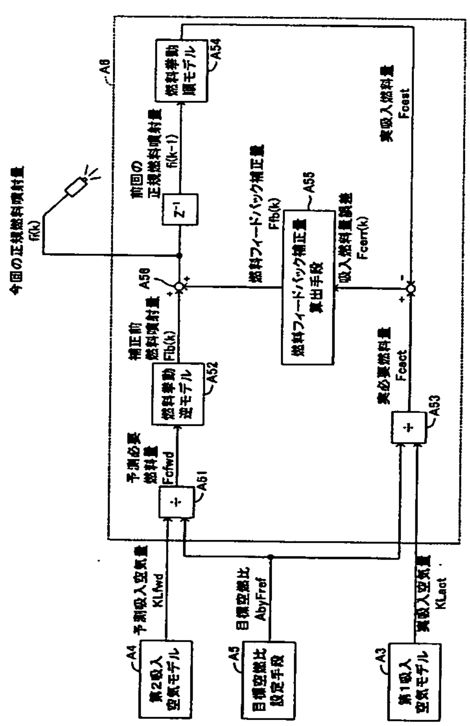
最終頁に続く

(54)【発明の名称】　内燃機関の燃料噴射量制御方法、及び燃料噴射量制御装置

(57)【要約】

【課題】　予測吸入空気量の推定誤差に基く供給燃料量の過不足分を迅速且つ正確に補償し、空燃比を一定に維持可能とすること。

【解決手段】　この燃料噴射量制御装置は、予測スロットル弁開度に基いて特定気筒の今回の吸気行程に対する吸入空気量KLfwdを予測し、これに基いて予測必要燃料量Fcfwdを求めるとともに、予測必要燃料量Fcfwdの燃料を供給するための補正前燃料噴射量Fibを燃料挙動逆モデルにより求める。一方、この制御装置は、前回の吸気行程に対する実スロットル弁開度に基いて実際の吸入空気量KLactを算出し、これに基いて実必要燃料量Fcactを求めるとともに、前回の吸気行程に対する実際の燃料噴射量fi(k−1)と燃料挙動順モデルとにより実吸入燃料量Fcestを求め、実必要燃料量Fcactと実吸入燃料量Fcestとの差Fcerrに応じて補正前燃料噴射量Fibを補正して今回の正規燃料噴射量fi(k)を求める。



【特許請求の範囲】

【請求項１】特定の気筒の今回の吸気行程での吸気弁閉弁時における内燃機関の運転状態量を同吸気弁閉弁時より前の時点で予測し、前記予測した運転状態量に応じて前記特定の気筒の今回の吸気行程での吸入空気量を予測し、前記予測した吸入空気量に対して所定の目標空燃比を得るために必要な燃料量を補正前燃料噴射量として算出するとともに、前記算出した補正前燃料噴射量に応じた量の燃料を前記特定の気筒の今回の吸気行程での吸気弁閉弁時よりも前の時点で同気筒に対して噴射する内燃機関の燃料噴射量制御方法であって、

前記特定の気筒の前回の吸気行程に対する吸気弁閉弁後の時点で、前記気筒の前回の吸気行程において前記目標空燃比を得るために前記気筒に実際に必要とされていた燃料量である実必要燃料量を既知となった運転状態量に基づいて求めるとともに、前記気筒の前回の吸気行程において前記気筒が実際に吸入した燃料量である実吸入燃料量を少なくとも前記気筒の前回の吸気行程に対し実際に噴射された燃料噴射量に基づいて算出し、前記実必要燃料量と前記実吸入燃料量とに基づいて前記気筒の前回の吸気行程における燃料の過不足分を求め、前記求められた過不足分に応じた補正量で前記補正前燃料噴射量を補正して正規燃料噴射量を算出し、前記算出された正規燃料噴射量の燃料を前記特定の気筒の今回の吸気行程に対して噴射する内燃機関の燃料噴射量制御方法。

【請求項２】指示に応じて燃料噴射を行う燃料噴射手段を備えた内燃機関の燃料噴射量制御装置において、

現時点より先の時点における前記内燃機関の運転状態量を予測する運転状態量予測手段と、

現時点より前の時点における前記内燃機関の実際の運転状態量を取得する運転状態量取得手段と、

特定の気筒の今回の吸気行程に対する吸気弁閉弁時より前の第１所定時点にて同気筒の今回の吸気行程での吸気弁閉弁時の吸入空気量である予測吸入空気量を前記運転状態量予測手段により予測された同第１所定時点より先の時点における運転状態量と前記内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する予測吸入空気量算出手段と、

前記第１所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第２所定時点にて前記予測吸入空気量に基づいて同気筒の今回の吸気行程に対し噴射すべき仮の噴射量である補正前燃料噴射量を算出する補正前燃料噴射量算出手段と、

前記気筒の前回の吸気行程での吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の第３所定時点にて同気筒の前回の吸気行程での吸気弁閉弁時の実際の吸入空気量である実吸入空気量を前記運転状態量取得手段により取得された実際の運転状態量と前記空気モデルとに基づいて算出する実吸入空気量算出手段と、

前記第３所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第４所定時点にて前記算出された実吸入空気量に基づいて同気筒の前回の吸気行程において同気筒に実際に必要とされていた燃料量である実必要燃料量を算出する実必要燃料量算出手段と、

前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第５所定時点にて同気筒の前回の吸気行程において同気筒が実際に吸入した燃料量である実吸入燃料量を少なくとも同気筒の前回の吸気行程に対し実際に噴射された燃料噴射量に基づいて算出する実吸入燃料量算出手段と、

前記第４所定時点、及び前記第５所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第６所定時点にて前記算出された実必要燃料量と前記算出された実吸入燃料量とに基づいて燃料フィードバック補正量を算出する燃料フィードバック補正量算出手段と、

前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第７所定時点にて前記算出された補正前燃料噴射量を前記算出された燃料フィードバック補正量で補正することにより前記燃料噴射手段から同気筒の今回の吸気行程に対し噴射する正規の燃料噴射量を算出する正規燃料噴射量算出手段と、

前記第７所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第８所定時点にて前記燃料噴射手段に対し前記算出された正規の燃料噴射量の燃料を噴射するように指示を与える燃料噴射指示手段と、

を備えた内燃機関の燃料噴射量制御装置。

【請求項３】請求項２に記載の内燃機関の燃料噴射量制御装置であって、

前記補正前燃料噴射量算出手段により算出される前記気筒の任意の吸気行程に対する補正前燃料噴射量と、同気筒の同任意の吸気行程の一回前の吸気行程後であって同任意の吸気行程前における予測された燃料付着量である予測燃料付着量と、前記内燃機関の吸気系への燃料付着挙動を表す燃料挙動モデルとに基づいて、同気筒の同任意の吸気行程後であって同任意の吸気行程の次の吸気行程前における予測燃料付着量を算出する予測燃料付着量算出手段と、

前記気筒の任意の吸気行程に対し実際に噴射された燃料噴射量と、同気筒の同任意の吸気行程の一回前の吸気行程後であって同任意の吸気行程前における実際の燃料付着量である実燃料付着量と、前記燃料挙動モデルとに基づいて、同気筒の同任意の吸気行程後であって同任意の吸気行程の次の吸気行程前における実燃料付着量を算出する実燃料付着量算出手段と、

を備えるとともに、

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前記補正前燃料噴射量算出手段は、
前記予測吸入空気量算出手段により算出された前記気筒の今回の吸気行程に対する吸気弁閉弁時の予測吸入空気量に基づいて同気筒の今回の吸気行程で同気筒に必要とされる燃料量である予測必要燃料量を算出し、且つ、
前記燃料挙動モデルの逆モデルに基づいて、前記気筒の今回の吸気行程に対し噴射すべき補正前燃料噴射量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量と前記予測燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量との和が前記算出された予測必要燃料量と等しくなるように同補正前燃料噴射量を算出するように構成され、
前記実吸入燃料量算出手段は、
前記燃料挙動モデルの順モデルに基づいて、前記気筒の前回の吸気行程に対し実際に噴射された燃料噴射量の燃料のうち同気筒の前回の吸気行程において同気筒に実際に吸入された燃料量と前記実燃料付着量算出手段により算出された同気筒の前々回の吸気行程後であって前回の吸気行程前における実燃料付着量の燃料のうち同気筒の前回の吸気行程において同気筒に実際に吸入された燃料量とから、同気筒の前回の吸気行程において同気筒が実際に吸入した前記実吸入燃料量を算出するように構成されてなる燃料噴射量制御装置。

【請求項４】指示に応じて燃料噴射を行う燃料噴射手段を備えた内燃機関の燃料噴射量制御装置において、
現時点より先の時点における前記内燃機関の運転状態量を予測する運転状態量予測手段と、
現時点より前の時点における前記内燃機関の実際の運転状態量を取得する運転状態量取得手段と、
特定の気筒の今回の吸気行程に対する吸気弁閉弁時より前の第１所定時点にて同気筒の今回の吸気行程での吸気弁閉弁時の吸入空気量である予測吸入空気量を前記運転状態量予測手段により予測された同第１所定時点より先の時点における運転状態量と前記内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する予測吸入空気量算出手段と、
前記第１所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第２所定時点にて前記予測吸入空気量に基づいて前記気筒の今回の吸気行程で同気筒に必要とされる燃料量である予測必要燃料量を算出するとともに、前記内燃機関の吸気系への燃料付着挙動を表す燃料挙動モデルの逆モデルにて使用する付着率と残留率を前記予測吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同逆モデルを使用することにより、同気筒の今回の吸気行程に対し噴射すべき仮の噴射量である補正前燃料噴射量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量と同気筒の前回の吸気行程後であって今回の吸気

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行程前における予測された燃料付着量である予測燃料付着量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量との和が、前記算出された予測必要燃料量と等しくなるように同補正前燃料噴射量を算出する補正前燃料噴射量算出手段と、
前記第２所定時点より前の第３所定時点にて、前記燃料挙動モデルにて使用する付着率と残留率を前記気筒の前回の吸気行程に対する予測吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同燃料挙動モデルと、同気筒の前々回の吸気行程後であって前回の吸気行程前における予測燃料付着量と、同気筒の前回の吸気行程に対する補正前燃料噴射量とに基づいて、同気筒の前回の吸気行程後であって今回の吸気行程前における前記予測燃料付着量を算出する予測燃料付着量算出手段と、
前記気筒の前回の吸気行程に対する吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の第４所定時点にて、同気筒の前回の吸気行程に対する吸気弁閉弁時の実際の吸入空気量である実吸入空気量を前記運転状態取得手段により取得された実際の運転状態量と前記空気モデルとに基づいて算出する実吸入空気量算出手段と、
前記第４所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第５所定時点にて、前記燃料挙動モデルにて使用する付着率と残留率を同気筒の前回の吸気行程に対する吸気弁閉弁時の実吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同燃料挙動モデルと、同気筒の前回の吸気行程に対し実際に噴射された燃料噴射量と、同気筒の前々回の吸気行程後であって前回の吸気行程前における実際の燃料付着量である実燃料付着量とに基づいて、同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量を算出する実燃料付着量算出手段と、
前記第３所定時点、及び前記第５所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第６所定時点にて、前記予測燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量と、前記実燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量とに基づいて燃料フィードバック補正量を算出する燃料フィードバック補正量算出手段と、
前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第７所定時点にて、前記算出された同気筒の今回の吸気行程に対し噴射すべき補正前燃料噴射量を前記算出された燃料フィードバック補正量で補正することにより前記燃料噴射手段から前記気筒の今回の吸気行程に対し噴射する正規の燃料噴射量を算出する正規燃料噴射量算出手段と、
前記第７所定時点より後の時点であって前記気筒の今回

の吸気行程に対する吸気弁閉弁時より前の第８所定時点にて前記燃料噴射手段に対し前記算出された正規の燃料噴射量の燃料を噴射するように指示を与える燃料噴射指示手段と、
を備えた内燃機関の燃料噴射量制御装置。

【発明の詳細な説明】

【０００１】
【発明の属する技術分野】本発明は、内燃機関の燃料噴射量制御装置に係り、特に過渡運転時においても空燃比を略一定に維持することが可能な燃料噴射量制御方法、及び燃料噴射量制御装置に関する。

【０００２】
【従来の技術】電子制御燃料噴射式の内燃機関においては、吸気行程直前又は吸気行程中にあって燃料噴射による燃料の供給が必要な気筒（以下、「燃料噴射気筒」と云う。）の同吸気行程における吸入空気量を求め、この求めた吸入空気量に応じた量の燃料を、最も遅くとも同吸気行程に対する吸気弁閉弁時（吸気弁の状態が開状態から閉状態に変化する時点）までに、場合によっては同吸気行程開始前までに、噴射する必要がある。このため、例えば、特開平１０－１６９４６９号公報に開示された内燃機関の制御装置は、同内燃機関の運転状態量の一つであるスロットル弁開度を燃料噴射気筒の吸気弁閉弁時まで前もって予測し、少なくとも同予測したスロットル弁開度と内燃機関の吸気系の空気の挙動をモデル化した空気モデルとに基づいて同燃料噴射気筒の吸気弁閉弁時における吸入空気量を同吸気弁閉弁時よりも前の時点で予測し、その予測した吸入空気量に応じた燃料噴射量の燃料を同気筒に対して噴射するようになっている。

【０００３】
【発明が解決しようとする課題】しかしながら、上記従来の制御装置は、例えば、予測したスロットル弁開度と実際のスロットル弁開度とが相違する等の理由により、予測した吸入空気量と実際の吸入空気量との間に差（推定誤差）が生じると、この推定誤差を補償する手段を備えていないので、燃料噴射量が適切な値と異なる値となって空燃比が乱れるという問題がある。従って、本発明の目的は、吸入空気量の推定誤差を迅速に補償し、特に、スロットル弁開度が急変する等の過渡運転時における空燃比を迅速に安定させることが可能な内燃機関の燃料噴射量制御方法、及び燃料噴射量制御装置を提供することにある。

【０００４】
【発明の概要】本発明の燃料噴射量制御方法は、特定の気筒の今回の吸気行程での吸気弁閉弁時における内燃機関の運転状態量を同吸気弁閉弁時より前の時点で予測し、前記予測した運転状態量に応じて前記特定の気筒の今回の吸気行程での吸入空気量を予測し、前記予測した吸入空気量に対して所定の目標空燃比を得るために必要な燃料量を補正前燃料噴射量として算出するとともに、前記算出した補正前燃料噴射量に応じた量の燃料を前記特定の気筒の今回の吸気行程での吸気弁閉弁時よりも前の時点で同気筒に対して噴射する内燃機関の燃料噴射量制御方法であって、前記特定の気筒の前回の吸気行程に対する吸気弁閉弁後の時点で、前記気筒の前回の吸気行程において前記目標空燃比を得るために前記気筒に実際に必要とされていた燃料量である実必要燃料量を既知となった運転状態量に基づいて求めるとともに、前記気筒の前回の吸気行程において前記気筒が実際に吸入した燃料量である実吸入燃料量を少なくとも前記気筒の前回の吸気行程に対し実際に噴射された燃料噴射量に基づいて算出し、前記実必要燃料量と前記実吸入燃料量とに基づいて前記気筒の前回の吸気行程における燃料の過不足分を求め、前記求められた過不足分に応じた補正量で前記補正前燃料噴射量を補正して正規燃料噴射量を算出し、前記算出された正規燃料噴射量の燃料を前記特定の気筒の今回の吸気行程に対して噴射する方法である。

【０００５】この燃料噴射量制御方法は、特定の気筒（内燃機関の複数気筒のうちの任意の一つの気筒、以下同じ。）の今回の吸気行程における吸気弁閉弁時の吸入空気量を、予測した運転状態量（例えば、スロットル弁開度）に基いて同吸気弁閉弁時よりも前の時点で予測し、予測した吸入空気量に基いて基本噴射量に相当する補正前燃料噴射量を算出する。従って、補正前燃料噴射量は、予測吸入空気量の予測誤差（推定誤差）の影響を受ける。

【０００６】一方、特定の気筒の前回の吸気行程の吸気弁閉弁後においては、同特定気筒の前回の吸気行程における吸気弁閉弁時点の運転状態量は既知であるから、その既知である運転状態量から同気筒の前回の吸気行程の実際の吸入空気量を求めることができ、従って、同特定気筒の前回の吸気行程で同特定気筒内の混合気の空燃比が目標空燃比となるために実際に必要とされていた燃料量（実必要燃料量）を正確に求めることができる。他方、前回の吸気行程の吸気弁閉弁後においては、同前回の吸気行程に対して実際に噴射された燃料噴射量が既知であるから、その既知である燃料噴射量に少なくとも基いて同気筒の前回の吸気行程の実際の吸入燃料量（実吸入燃料量）を正確に求めることができる。

【０００７】本燃料噴射量制御方法は、このように実必要燃料量と実吸入燃料量を求め、これら実必要燃料量と実吸入燃料量（との差）に基いて前回の吸気行程における燃料の過不足を算出し、同加不足分を補うための補正量を求めて前記補正前燃料噴射量を補正する。従って、各気筒毎に、且つ吸気行程毎に、前回の吸気行程での燃料の過不足分が少なくとも今回の吸気行程で補償されるので、空燃比を迅速、且つ、精度良く、一定に維持することができる。

【０００８】また、より具体的態様としての本発明の内燃機関の燃料噴射量制御装置（以下、「第１燃料噴射量

制御装置」と称呼する。）は、指示に応じて燃料噴射を行う燃料噴射手段を備えた内燃機関の燃料噴射量制御装置であって、運転状態量予測手段、運転状態量取得手段、予測吸入空気量算出手段、補正前燃料噴射量算出手段、実吸入空気量算出手段、実必要燃料量算出手段、実吸入燃料量算出手段、燃料フィードバック補正量算出手段、正規燃料噴射量算出手段、及び燃料噴射指示手段を備える。以下、各手段の作用について説明する。

【０００９】運転状態量予測手段は、現時点より先の時点における前記内燃機関の運転状態量を予測する。運転状態量取得手段は、現時点より前の時点における前記内燃機関の実際の運転状態量を取得する。運転状態量の代表例としては、スロットル弁開度が挙げられる。

【００１０】予測吸入空気量算出手段は、特定の気筒（ある気筒）の今回の吸気行程に対する吸気弁閉弁時より前の第１所定時点にて、同気筒の今回の吸気行程での吸気弁閉弁時の吸入空気量である予測吸入空気量を前記運転状態量予測手段により予測された同第１所定時点より先の時点における運転状態量と前記内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する。即ち、予測吸入空気量算出手段は、次に吸気行程に入ろうとしている（又は、すでに吸気行程に入っている）気筒の吸気弁がその吸気行程において開弁状態から閉弁状態へと以降する時点（吸気弁閉弁時）より前の第１所定時点で、同吸気弁閉弁時における同気筒の吸入空気量を予測する。

【００１１】補正前燃料噴射量算出手段は、前記第１所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第２所定時点にて、前記予測吸入空気量に基づいて同気筒の今回の吸気行程に対し噴射すべき仮の噴射量である補正前燃料噴射量を算出する。例えば、補正前燃料噴射量算出手段は、内燃機関の運転状態に応じて別途定められる（或いは一定の）目標空燃比で前記予測吸入空気量を除することにより補正前燃料噴射量を算出することができる。この場合、後述するように、燃料付着量を考慮して補正前燃料噴射量を求めることが好適である。

【００１２】実吸入空気量算出手段は、前記気筒の前回の吸気行程での吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の第３所定時点にて、同気筒の前回の吸気行程での吸気弁閉弁時の実際の吸入空気量である実吸入空気量を前記運転状態量取得手段により取得された実際の運転状態量と前記空気モデルとに基づいて算出する。この第３所定時点は、前記気筒の前回の吸気行程での吸気弁閉弁時より後の時点であるから、同気筒の前回の吸気行程での吸気弁閉弁時の実際の吸入空気量を求めるための運転状態量は既知であり、前記運手状態量取得手段により取得される。従って、実吸入空気量は同既知の運転状態量と空気モデルとに基いて正確に求められる。

【００１３】実必要燃料量算出手段は、前記第３所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第４所定時点にて、前記算出された実吸入空気量に基づいて同気筒の前回の吸気行程において同気筒に実際に必要とされていた燃料量である実必要燃料量を算出する。例えば、実必要燃料算出手段は、前記補正前燃料噴射量算出手段と同様、前記目標空燃比で前記実吸入空気量を除すことにより実必要燃料量を算出することができる。

【００１４】実吸入燃料量算出手段は、前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第５所定時点にて、同気筒の前回の吸気行程において同気筒が実際に吸入した燃料量である実吸入燃料量を少なくとも同気筒の前回の吸気行程に対し実際に噴射された燃料噴射量に基づいて算出する。この場合、後述するように、実際に噴射された燃料噴射量として正規の燃料噴射量（正規燃料噴射量）を採用することもでき、更に、実際の燃料付着量（実燃料付着量）を考慮して実吸入燃料量を求めることが好適である。

【００１５】燃料フィードバック補正量算出手段は、前記第４所定時点、及び前記第５所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第６所定時点にて、前記算出された実必要燃料量と前記算出された実吸入燃料量とに基づいて燃料フィードバック補正量を算出する。

【００１６】例えば、前記算出された実必要燃料量と前記算出された実吸入燃料量との差は、前回の吸気行程における燃料の過不足分を表すから、同実必要燃料量と同実吸入燃料量との差と、この差を入力値とする比例積分制御等のコントローラとを用いることで、同燃料の過不足分を補償する燃料フィードバック補正量が算出される。

【００１７】正規燃料噴射量算出手段は、前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第７所定時点にて、前記算出された補正前燃料噴射量を前記算出された燃料フィードバック補正量で補正することにより前記燃料噴射手段から同気筒の今回の吸気行程に対し噴射する正規の燃料噴射量を算出する。

【００１８】そして、燃料噴射指示手段は、前記第７所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第８所定時点にて、前記燃料噴射手段に対し前記算出された正規の燃料噴射量の燃料を噴射するように指示を与え、これにより、正規の燃料噴射量の燃料が燃料噴射手段から噴射される。

【００１９】第１燃料噴射量制御装置は、以上の処理を各気筒の吸気行程毎に各気筒毎に繰り返し実行し、特定の気筒の前回の吸気行程における燃料の過不足分を同特定の気筒の次回以降の燃料噴射量に直ちに反映する（補償する）ので、空燃比を安定した値に維持することがで

きる。

【００２０】この場合、上記第１燃料噴射量制御装置は、予測燃料付着量を算出する予測燃料付着量算出手段を備え、前記補正前燃料噴射量算出手段は予測必要燃料量を算出するとともに、この予測必要燃料量が供給されるように、前記算出された予測燃料付着量を考慮しながら燃料挙動モデルの逆モデルを使用して前記補正前燃料噴射量を算出するように構成され、更に、実燃料付着量を算出する実燃料付着量算出手段を備え、この実燃料付着量を考慮しながら燃料挙動モデルの順モデルを使用して前記実吸入燃料量を算出するように構成されることが好適である。

【００２１】これによれば、機関の運転状態に応じて変化する燃料付着量が考慮されながら燃料噴射量が決定されて行くから、各気筒に対して適切な正規の燃料噴射量が算出され、その結果、空燃比を一層安定化することができる。

【００２２】より具体的に述べると、予測燃料付着量算出手段は、前記補正前燃料噴射量算出手段により算出される前記気筒の任意の吸気行程に対する補正前燃料噴射量と、同気筒の同任意の吸気行程の一回前の吸気行程後であって同任意の吸気行程前における予測された燃料付着量である予測燃料付着量と、前記内燃機関の吸気系への燃料付着挙動を表す燃料挙動モデルとに基づいて、同気筒の同任意の吸気行程後であって同任意の吸気行程の次の吸気行程前における予測燃料付着量を算出する。

【００２３】即ち、予測燃料付着量算出手段は、ある吸気行程に対して補正前燃料噴射量の燃料が噴射されたと仮定した場合において、同補正前燃料噴射量の燃料のうちの吸気系に付着する燃料の量と、その吸気行程前に吸気系に付着していたと予測される予測燃料付着量のうちの吸気系に残留する燃料の量とから、新たな（即ち、前記ある吸気行程後の）予測燃料付着量を算出する。

【００２４】実燃料付着量算出手段は、前記気筒の任意の吸気行程に対し実際に噴射された燃料噴射量と、同気筒の同任意の吸気行程の一回前の吸気行程後であって同任意の吸気行程前における実際の燃料付着量である実燃料付着量と、前記燃料挙動モデルとに基づいて、同気筒の同任意の吸気行程後であって同任意の吸気行程の一回後の吸気行程前における実燃料付着量を算出する。

【００２５】即ち、実燃料付着量算出手段は、ある吸気行程に対して実際に噴射された燃料噴射量の燃料のうちの吸気系に付着する燃料の量と、その吸気行程前に吸気系に付着していた実燃料付着量のうちの吸気系に残留する燃料の量とから、新たな（前記ある吸気行程後の）実燃料付着量を算出する。

【００２６】そして、前記補正前燃料噴射量算出手段は、前記予測吸入空気量算出手段により算出された前記気筒の今回の吸気行程に対する吸気弁閉弁時の予測吸入空気量に基づいて同気筒の今回の吸気行程で同気筒に必要とされる燃料量である予測必要燃料量を算出し、且つ、前記燃料挙動モデルの逆モデルに基づいて、前記気筒の今回の吸気行程に対し噴射すべき補正前燃料噴射量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量と前記予測燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量との和が前記算出された予測必要燃料量と等しくなるように同補正前燃料噴射量を算出するように構成される。

【００２７】即ち、前記補正前燃料噴射量算出手段は、予測された今回の吸気行程に対する吸気弁閉弁時の予測吸入空気量から、同今回の吸気行程で必要とされる燃料量（予測必要燃料量）を算出し、この予測必要燃料量が気筒に吸入されるためには、どれだけの燃料噴射量の燃料を噴射しなければならないかを、同燃料噴射量の燃料のうち吸入系へ付着することなく気筒に吸入される分、及び今回の吸気行程前における予測された予測燃料付着量の燃料のうちの同気筒への吸入される分とを考慮して算出し、そのようにして算出された燃料噴射量を補正前燃料噴射量とする。

【００２８】また、前記実吸入燃料量算出手段は、前記燃料挙動モデルの順モデルに基づいて、前記気筒の前回の吸気行程に対し実際に噴射された燃料噴射量の燃料のうち同気筒の前回の吸気行程において同気筒に実際に吸入された燃料量、及び、前記実燃料付着量算出手段により算出された同気筒の前々回の吸気行程後であって前回の吸気行程前における実燃料付着量の燃料のうち同気筒の前回の吸気行程において同気筒に実際に吸入された燃料量から、同気筒の前回の吸気行程において同気筒が実際に吸入した前記実吸入燃料量を算出するように構成される。

【００２９】即ち、前記実吸入燃料量算出手段は、前回の吸気行程に対する実際の燃料噴射量の燃料のうち気筒に吸入される分と、前回の吸気行程前の実際の燃料付着量の燃料のうち気筒に吸入される分との和を、前回の吸気行程において実際に吸入された吸入燃料量として算出する。

【００３０】このようにすれば、燃料付着量が考慮されて補正前燃料噴射量が算出されるので、吸入空気量の予測誤差がない場合には同補正前燃料噴射量の燃料供給によって実必要燃料量に極めて近い燃料量の燃料が供給されることになり、各吸気行程毎の空燃比が安定する。更に、燃料付着量が考慮されることで、実吸入燃料量が精度良く求められるので、吸入された燃料の過不足分が正確に求められ、この過不足分がフィードバック補正量に反映されるから、結果として空燃比をより一層安定させることができる。

【００３１】本発明による他の態様に係る内燃機関の燃料噴射量制御装置（以下、「第２燃料噴射量制御装置」

と称呼する。）は、ある気筒（特定の気筒）の前回の吸気行程において実際に噴射された既知の燃料噴射量（実燃料噴射量）と、同気筒の前回の吸気行程前の実際の燃料付着量（実燃料付着量）と、燃料挙動モデルとに基づいて今回の吸気行程前における実燃料付着量を求める。このとき、燃料挙動モデルの付着率及び残留率は、前回の吸気行程に対する吸気弁閉弁時後において既知となった運転状態量と空気モデルとに基づいて求められた同前回の吸気行程に対する吸気弁閉弁時の実際の吸入空気量（実吸入空気量）に基いて決定される。これにより、実燃料付着量は、実際の吸入空気量に基いて求められた燃料挙動モデルの付着率と残留率と、実際の燃料噴射量とに基づいて算出されるから、実際の燃料付着量を精度良く表す量となる。

【００３２】一方、第２燃料噴射量制御装置は、前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の時点で同吸気弁閉弁時の吸入空気量を予測するとともに、その予測された吸入空気量に応じた予測必要燃料量が得られるように、同今回の吸気行程前における予測燃料付着量を考慮しながら補正前燃料噴射量を求める。このとき、第２燃料噴射量制御装置は、燃料挙動モデルにて使用する付着率と残留率とを同気筒の前回の吸気行程に対する（補正前燃料噴射量を算出する基礎となった）予測吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同燃料挙動モデルと、同気筒の前々回の吸気行程後であって同気筒の前回の吸気行程前の予測燃料付着量と、前回の吸気行程に対する補正前燃料噴射量とに基づいて、前記気筒の今回の吸気行程前における予測燃料付着量を予測する。この結果、予測燃料付着量は前回の吸気行程に対する予測吸入空気量が反映された値となる。

【００３３】そして、第２燃料噴射量制御装置は、今回の吸気行程前における前記実燃料付着量と、同今回の吸気行程前における前記予測燃料付着量と、に基づいて前回の吸気行程における燃料の過不足分に応じた値（即ち、予測吸入空気量の実吸入空気量に対する誤差を反映した値）を求め、その値に応じて今回の吸気行程に対する燃料フィードバック補正量を算出し、同燃料フィードバック補正量によって補正前燃料噴射量を補正する。以上により、空燃比を安定化させることができる。

【００３４】より具体的に述べると、第２燃料噴射量制御装置は、指示に応じて燃料噴射を行う燃料噴射手段を備えた内燃機関の燃料噴射量制御装置であって、運転状態量予測手段、運転状態量取得手段、予測吸入空気量算出手段、補正前燃料噴射量算出手段、予測燃料付着量算出手段、実吸入空気量算出手段、実燃料付着量算出手段、燃料フィードバック補正量算出手段、正規燃料噴射量算出手段、及び燃料噴射指示手段を備える。以下、各手段の作用について説明する。

【００３５】運転状態量予測手段は、現時点より先の時点における前記内燃機関の運転状態量を予測する。運転状態量取得手段は、現時点より前の時点における前記内燃機関の実際の運転状態量を取得する。運転状態量の代表例としては、スロットル弁開度が挙げられる。

【００３６】予測吸入空気量算出手段は、特定の気筒の今回の吸気行程に対する吸気弁閉弁時より前の第１所定時点にて同気筒の今回の吸気行程での吸気弁閉弁時の吸入空気量である予測吸入空気量を前記運転状態量予測手段により予測された同第１所定時点より先の時点における運転状態量と前記内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する。即ち、予測吸入空気量算出手段は、第１燃料噴射量制御装置のそれと同様に、次に吸気行程に入ろうとしている（又は、すでに吸気行程に入っている）気筒の吸気弁がその吸気行程において開弁状態から閉弁状態へと以降する時点（吸気弁閉弁時）より前の第１所定時点で、同吸気弁閉弁時における同気筒の吸入空気量を予測する。

【００３７】補正前燃料噴射量算出手段は、前記第１所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第２所定時点にて前記予測吸入空気量に基づいて前記気筒の今回の吸気行程で同気筒に必要とされる燃料量である予測必要燃料量を算出する。例えば、補正前燃料噴射量算出手段は、内燃機関の運転状態に応じて別途定められる（或いは一定の）目標空燃比で前記予測吸入空気量を除することにより予測必要燃料量を算出することができる。

【００３８】更に、補正前燃料噴射量算出手段は、前記内燃機関の吸気系への燃料付着挙動を表す燃料挙動モデルの逆モデルにて使用する付着率と残留率を前記予測吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同逆モデルを使用することにより、同気筒の今回の吸気行程に対し噴射すべき仮の噴射量である補正前燃料噴射量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量と同気筒の前回の吸気行程後であって今回の吸気行程前における予測された燃料付着量である予測燃料付着量の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量との和が、前記算出された予測必要燃料量と等しくなるように同補正前燃料噴射量を算出する。

【００３９】予測燃料付着量算出手段は、前記第２所定時点より前の第３所定時点にて、前記燃料挙動モデルにて使用する付着率と残留率を前記気筒の前回の吸気行程に対する予測吸入空気量（即ち、前回の吸気行程に対する吸気弁閉弁時より前の時点で同前回の吸気行程に対する吸気弁閉弁時の吸入空気量として前記予測吸入空気量算出手段が算出した吸入空気量）に基いて決定し、同決定した付着率と残留率を使用した同燃料挙動モデルと、同気筒の前々回の吸気行程後であって前回の吸気行程前における予測燃料付着量と、同気筒の前回の吸気行程に対する補正前燃料噴射量とに基づいて、同気筒の前回の

吸気行程後であって今回の吸気行程前における前記予測燃料付着量を算出する。

【００４０】実吸入空気量算出手段は、前記気筒の前回の吸気行程に対する吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の第４所定時点にて、同気筒の前回の吸気行程に対する吸気弁閉弁時の実際の吸入空気量である実吸入空気量を前記運転状態取得手段により取得された実際の運転状態量と前記空気モデルとに基づいて算出する。この第４所定時点は、前記気筒の前回の吸気行程での吸気弁閉弁時より後の時点であるから、同気筒の前回の吸気行程での吸気弁閉弁時の実際の吸入空気量を求めるための運転状態量は既知であり、前記運手状態量取得手段により取得される。従って、実吸入空気量は既知の運転状態量と空気モデルとによって正確に求められる。

【００４１】実燃料付着量算出手段は、前記第４所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第５所定時点にて、前記燃料挙動モデルにて使用する付着率と残留率を同気筒の前回の吸気行程に対する吸気弁閉弁時の実吸入空気量に基いて決定し、同決定した付着率と残留率を使用した同燃料挙動モデルと、同気筒の前回の吸気行程に対し実際に噴射された燃料噴射量と、同気筒の前々回の吸気行程後であって前回の吸気行程前における実際の燃料付着量である実燃料付着量とに基づいて、同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量を算出する。このように実燃料付着量は、実吸入空気量と実燃料噴射量に基づいて算出されるから、同実燃料付着量は真の燃料付着量と極めて近しい量となる。

【００４２】燃料フィードバック補正量算出手段は、前記第３所定時点、及び前記第５所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第６所定時点にて、前記予測燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量と、前記実燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量とに基づいて燃料フィードバック補正量を算出する。

【００４３】即ち、前記算出された予測燃料付着量は予測吸入空気量を反映した値であり、前記算出された実燃料付着量は実吸入空気量を反映した値であるから、前記予測燃料付着量と前記実燃料付着量との差は、前回の吸気行程における吸入空気量の推定誤差、従って、燃料の過不足分を表す。従って、前記予測燃料付着量と前記実燃料噴射量とが一致するように、例えば、比例積分制御等のコントローラで燃料フィードバック補正量を算出すれば、同燃料フィードバック補正量は燃料の過不足分を補償する値となる。

【００４４】正規燃料噴射量算出手段は、前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第７所定時点にて、前記算出された同気筒の今回の吸気行程に対し噴射すべき補正前燃料噴射量を前記算出された燃料フィードバック補正量で補正することにより前記燃料噴射手段から前記気筒の今回の吸気行程に対し噴射する正規の燃料噴射量を算出する。

【００４５】そして、燃料噴射指示手段は、前記第７所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第８所定時点にて前記燃料噴射手段に対し前記算出された正規の燃料噴射量の燃料を噴射するように指示を与え、これにより、正規の燃料噴射量の燃料が燃料噴射手段から噴射される。

【００４６】第２燃料噴射量制御装置は、以上の処理を各気筒の吸気行程毎に繰り返し実行し、各気筒毎の前回の吸気行程における燃料の過不足分を次回以降の各気等の燃料噴射量に反映し補償するので、空燃比を安定した値に維持することができる。

【００４７】なお、上記第１、及び第２燃料噴射量制御装置の何れにおいても、上記第８の所定時点は、実際には、燃料噴射に要する時間と、噴射された燃料が気筒内に吸入されるのに要する時間と、の和の時間だけ、吸気弁閉弁時よりも前の時点である必要がある。但し、筒内噴射式の内燃機関の場合、或いは、燃料噴射手段としてのインジェクタの流量が極めて大きい場合等においては、第８の所定時点は吸気弁閉弁時より前の所定時点であればよい。また、第８の所定時間は、燃料噴射開始後であってもよい。

【００４８】

【発明の実施の形態】以下、本発明による内燃機関の制御装置の各実施形態について図面を参照しつつ説明する。図１は、本発明の第１実施形態に係る燃料噴射量制御装置（第１燃料噴射量制御装置）を火花点火式多気筒（４気筒）内燃機関１０に適用したシステムの概略構成を示している。

【００４９】この内燃機関１０は、シリンダブロック、シリンダブロックロワーケース、及びオイルパン等を含むシリンダブロック部２０と、シリンダブロック部２０の上に固定されるシリンダヘッド部３０と、シリンダブロック部２０にガソリン混合気を供給するための吸気系統４０と、シリンダブロック部２０からの排ガスを外部に放出するための排気系統５０とを含んでいる。

【００５０】シリンダブロック部２０は、シリンダ２１、ピストン２２、コンロッド２３、及びクランク軸２４を含んでいる。ピストン２２はシリンダ２１内を往復動し、ピストン２２の往復動がコンロッド２３を介してクランク軸２４に伝達され、これにより同クランク軸２４が回転するようになっている。シリンダ２１とピストン２２のヘッドは、シリンダヘッド部３０とともに燃焼室２５を形成している。

【００５１】シリンダヘッド部３０は、燃焼室２５に連

通した吸気ポート３１、吸気ポート３１を開閉する吸気弁３２、吸気弁３２を駆動するインテークカムシャフトを含むとともに同インテークカムシャフトの位相角を連続的に変更する可変吸気タイミング装置３３、可変吸気タイミング装置３３のアクチュエータ３３ａ、燃焼室２５に連通した排気ポート３４、排気ポート３４を開閉する排気弁３５、排気弁３５を駆動するエキゾーストカムシャフト３６、点火プラグ３７、点火プラグ３７に与える高電圧を発生するイグニッションコイルを含むイグナイタ３８、及び燃料を吸気ポート３１内に噴射するインジェクタ（燃料噴射手段）３９を備えている。

【００５２】吸気系統４０は、吸気ポート３１に連通し同吸気ポート３１とともに吸気通路を形成するインテークマニホールドを含む吸気管４１、吸気管４１の端部に設けられたエアフィルタ４２、吸気管４１内にあって吸気通路の開口断面積を可変とするスロットル弁４３、スロットル弁駆動手段を構成するスロットル弁アクチュエータ４３ａ、スワールコントロールバルブ（以下、「ＳＣＶ」と称呼する。）４４、及びＳＣＶアクチュエータ４４ａを備えている。

【００５３】ＤＣモータからなるスロットル弁アクチュエータ４３ａは、後述する電子制御装置７０が達成する電子制御スロットル弁ロジックにより目標スロットル弁開度TAtが与えられると、実際のスロットル弁開度TAが目標スロットル弁開度TAtとなるようにスロットル弁４３を駆動するようになっている。

【００５４】ＤＣモータからなるＳＣＶアクチュエータ４４ａは、電気制御装置７０から駆動信号を受け、前記スロットル弁４３よりも下流で前記インジェクタ３９よりも上流の位置にて前記吸気管４１に対し回動可能に支持され、燃焼室に吸入される空気にスワールを発生させるためのＳＣＶ４４を回転駆動するようになっている。

【００５５】排気系統５０は、排気ポート３４に連通したエキゾーストマニホールド５１、エキゾーストマニホールド５１に接続されたエキゾーストパイプ５２、及びエキゾーストパイプ５２に介装された触媒コンバータ（三元触媒装置）５３を備えている。

【００５６】一方、このシステムは、熱線式エアフローメータ６１、吸気温センサ６２、大気圧センサ（スロットル弁上流圧力センサ）６３、スロットルポジションセンサ６４、SCV開度センサ６５、カムポジションセンサ６６、クランクポジションセンサ６７、水温センサ６８、空燃比センサ６９、及びアクセル操作量検出手段（の一部）を構成するアクセル開度センサ８１を備えている。

【００５７】エアフローメータ６１は、概略斜視図である図２に示したように、吸気管４１内を流れる吸入空気の一部をバイパスさせるバイパス通路と、このバイパス通路にバイパスされた吸入空気の質量流量を計測する熱線計量部６１ａと、計測された質量流量に応じた電圧Vgを出力する信号処理部６１ｂとからなっている。熱線計量部６１ａは、その拡大斜視図である図３に示したように、白金熱線からなる吸気温計測用抵抗（ボビン部）６１ａ１と、同吸気温計測用抵抗６１ａ１を前記信号処理部６１ｂに連結して保持するサポート部６１ａ２と、加熱用抵抗（ヒータ）６１ａ３と、同加熱用抵抗６１ａ３を前記信号処理部６１ｂに連結して保持するサポート部６１ａ４とを備えている。信号処理部６１ｂは、吸気温計測用抵抗６１ａ１と加熱用抵抗６１ａ３とで構成されたブリッジ回路を備え、このブリッジ回路により吸気温計測用抵抗６１ａ１と加熱用抵抗６１ａ３との温度差を常に一定に維持するように同加熱用抵抗６１ａ３に供給する電力を調整するとともに、この供給する電力を前記電圧Vgに変換して出力するようになっている。かかるエアフローメータ６１の出力Vgと、計測された吸入空気流量mtAFMとの関係は、例えば図４に示したとおりであり、電気制御装置７０は同図４の関係を利用することにより、計測された吸入空気流量mtAFMの値を取得するようになっている。

【００５８】吸気温センサ６２は、エアフローメータ６１内に備えられていて、吸入空気の温度（吸気温度）を検出し、吸気温度THAを表す信号を出力するようになっている。大気圧センサ６３は、スロットル弁４３の上流の圧力（即ち、大気圧）を検出し、スロットル弁上流圧力Paを表す信号を出力するようになっている。スロットルポジションセンサ６４は、スロットル弁４３の開度を検出し、スロットル弁開度TAを表す信号を出力するようになっている。SCV開度センサ６５は、ＳＣＶ４４の開度を検出し、ＳＣＶ開度θivを表す信号を出力するようになっている。カムポジションセンサ６６は、インテークカムシャフトが９０°回転する毎に（即ち、クランク軸２４が１８０°回転する毎に）一つのパルスを有する信号（Ｇ２信号）を発生するようになっている。クランクポジションセンサ６７は、クランク軸２４が１０°回転する毎に幅狭のパルスを有するとともに同クランク軸２４が３６０°回転する毎に幅広のパルスを有する信号を出力するようになっている。この信号は、エンジン回転速度NEを表す。水温センサ６８は、内燃機関１０の冷却水の温度を検出し、冷却水温THWを表す信号を出力するようになっている。空燃比センサ６９は、触媒コンバータ５３に流入する排ガス中の酸素濃度を検出することで空燃比を表す信号を出力するようになっている。アクセル開度センサ８１は、運転者によって操作されるアクセルペダル８２の操作量を検出し、同アクセルペダルの操作量Accpを表す信号を出力するようになっている。

【００５９】電気制御装置７０は、互いにバスで接続されたＣＰＵ７１、ＣＰＵ７１が実行するプログラム、テーブル（ルックアップテーブル、マップ）、定数等を予め記憶したＲＯＭ７２、ＣＰＵ７１が必要に応じてデータを一時的に格納するＲＡＭ７３、電源が投入された状

態でデータを格納するとともに同格納したデータを電源が遮断されている間も保持するバックアップＲＡＭ７４、及びＡＤコンバータを含むインターフェース７５等からなるマイクロコンピュータである。インターフェース７５は、前記センサ６１～６９，８１と接続され、ＣＰＵ７１にセンサ６１～６９，８１からの信号を供給するとともに、同ＣＰＵ７１の指示に応じて可変吸気タイミング装置３３のアクチュエータ３３ａ、イグナイタ３８、インジェクタ３９、スロットル弁アクチュエータ４３ａ、及びＳＣＶアクチュエータ４４ａに駆動信号を送出するようになっている。

【００６０】次に、上記のように構成された制御装置による物理モデルを用いた燃料噴射量の決定方法について説明する。以下に述べる処理は、ＣＰＵ７１がプログラムを実行することにより行われる。

【００６１】（燃料噴射量fiの決定方法の概要）このような燃料噴射量制御装置は、吸気行程にある気筒、又は吸気行程の直前の状態にある気筒（即ち、燃料噴射気筒）の吸気弁３２が、その吸気行程において開弁した状態から閉弁する状態に移行する時点（吸気弁閉弁時）より前の時点にて、同気筒に対して所定量の燃料を噴射する必要がある。そのため、本燃料噴射量制御装置は、吸気弁３２が閉弁状態に移行する時点において同気筒内に吸入されているであろう吸入空気量を前もって予測し、同予測した吸入空気量に応じた燃料量の燃料を同吸気弁３２の閉弁時より前の時点で同気筒に対して噴射する。本例においては、噴射終了時期を、燃料噴射気筒の吸気上死点前７５°クランクアングル（以下、「BTDC７５°CA」と表す。他のクランクアングルについても同様に表す。）と定めている。従って、本制御装置は、噴射に要する時間（インジェクタの開弁時間）、ＣＰＵの計算時間を考慮して、BTDC７５°CAの時点よりも前の時点にて、燃料噴射気筒の吸入空気量を予測する。

【００６２】一方、吸気弁閉弁時の吸気管圧力（即ち、吸気管内空気圧力）は、吸入空気量と密接な関係にある。また、吸気弁閉弁時の吸気管圧力は、吸気弁閉弁時のスロットル弁開度に依存する。そこで、本制御装置は、吸気弁閉弁時のスロットル弁開度を予測・推定し、そのスロットル弁開度に基づいて燃料噴射気筒の吸入空気量KLfwdを事前に予測し、下記数１に示したように、予測した吸入空気量KLfwdをエンジンの運転状態に応じて別途定められる目標空燃比AbyFrefで除することで仮の燃料噴射量（補正前燃料噴射量）fibを決定するとともに、燃料フィードバック補正量Ffbを別途求め、補正前燃料噴射量Fibを燃料フィードバック補正量Ffbにより補正して正規の燃料噴射量fiを求める。燃料フィードバック補正量Ffbは、後に詳述するように、前回の吸気行程において実際に必要とされた燃料量（実必要燃料量）と同前回の吸気行程において実際に吸入された燃料量（実吸入燃料量）との差に基く値である。以上が、正規燃料噴射量（最終的に噴射される燃料の量）fiを求める方法の概要である。

【００６３】

【数１】$fi = KLfwd / AbyFref + Ffb = Fib + Ffb$

【００６４】（具体的構成・作用）以下、上記数１に示した燃料噴射量fiを求めるための燃料噴射量制御装置の具体的構成、及び作用について説明する。この燃料噴射量制御装置は、機能ブロック図である図５に示したように、電子制御スロットル弁ロジックＡ１、現時点より前の時点（過去～現在）における実際のスロットル弁開度と実際のアクセル操作量等の内燃機関の運転状態量を取得する運転状態量取得手段Ａ２、現時点より先の時点におけるスロットル弁開度等の内燃機関の運転状態量を予測する運転状態量予測手段Ｍ１、内燃機関の吸気系における空気の挙動をモデル化した空気モデルを含む実吸入空気量算出手段としての第１吸入空気モデルＡ３、同空気モデルを含む予測吸入空気量算出手段としての第２吸入空気モデルＡ４、目標空燃比設定手段Ａ５、及び図６に詳細な機能ブロック図を示した噴射量決定手段Ａ６を含んでいる。以下、個別具体的に、各手段、及びモデル等について説明する。

【００６５】（電子制御スロットル弁ロジックと電子制御スロットル弁モデル）先ず、スロットル弁開度を制御するための電子制御スロットル弁ロジックＡ１と、将来における（現時点よりも先の時点における）スロットル弁開度TAestを予測する電子制御スロットル弁モデルＭ１について説明する。

【００６６】電子制御スロットル弁ロジックＡ１は、先ず、演算周期ΔTt（例えば、８msec）の経過毎にアクセル開度センサ８１の出力値に基づいてアクセル操作量Accpを読込み、読み込んだアクセル操作量Accpと図７のアクセル操作量Accpと目標スロットル弁開度TAaccとの関係を規定したテーブルとに基づいて今回の暫定目標スロットル弁開度TAaccを求め、この暫定目標スロットル弁開度TAaccを図８のタイムチャートに示したように、所定の遅延時間TDだけ遅延し、この遅延した暫定目標スロットル弁開度TAaccを目標スロットル弁開度TAtとして設定してスロットル弁アクチュエータ４３ａに出力する。なお、遅延時間TDは、本例においては一定の時間であるが、内燃機関が所定のクランク角度（例えば、クランク角２７０°CA）だけ回転するのに要する時間T270とする等、エンジン回転速度NEに応じた可変の時間とすることもできる。

【００６７】ところで、電子制御スロットル弁ロジックＡ１から目標スロットル弁開度TAtがスロットル弁アクチュエータ４３ａに出力された場合であっても、同スロットル弁アクチュエータ４３ａの遅れや、スロットル弁４３の慣性などにより、実際のスロットル弁開度TAは、ある遅れをもって目標スロットル弁開度TAtに追従する。そこで、電子制御スロットル弁モデルＭ１において

は、下記数２に基づいて遅延時間TD後におけるスロットル弁開度を予測・推定する（図８を参照）。
【００６８】
【数２】
$$TAest(k+1)=TAest(k)+\Delta Tt \cdot f\ (TAt(k),\ TAest(k))$$
【００６９】数２において、TAest(k+1)は今回の演算タイミングにおいて新たに予測・推定される予測スロットル弁開度TAestであり、TAt(k)は今回の演算タイミングにて新たに得られた目標スロットル弁開度TAtであり、TAest(k)は今回の演算タイミングにおいて既に予測・推定されていた最新の予測スロットル弁開度TAest（即ち、前回の演算タイミングにおいて予測・推定されたスロットル弁開度TAest）である。また、関数ｆ（TAt(k)，TAest(k))は、図９に示したように、TAt(k)とTAest(k)との差ΔTA（＝TAt(k)－TAest(k))が大きい程大きい値をとる関数（ΔTAに関して単調増加する関数ｆ）である。
【００７０】このように、電子制御スロットル弁モデルＭ１（ＣＰＵ７１）は、今回の演算タイミングにて遅延時間TD後の目標スロットル弁開度TAtを新たに決定するとともに、遅延時間TD後のスロットル弁開度TAestを新たに予測・推定し、現時点から遅延時間TD経過後までの目標スロットル弁開度TAtと予測スロットル弁開度TAestを、現時点からの時間経過に対応させた形でＲＡＭ７３に記憶・格納する。
【００７１】＜第１吸入空気モデル（実吸入空気量算出手段）Ａ３＞第１吸入空気モデルＡ３は、内燃機関の吸気系における空気の挙動をモデル化した空気モデルを構成するスロットルモデルＭ２、吸気弁モデルＭ３、吸気管モデルＭ４、及び吸気弁モデルＭ５を備えていて、特定気筒の前回の吸気行程での吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の時点にて同気筒の前回の吸気行程での吸気弁閉弁時の実際の吸入空気量である実吸入空気量KLactを、前記運転状態量取得手段Ａ２により取得された実際の運転状態量である実際のスロットル弁開度（実スロットル弁開度TAact）に基いて求める。上記スロットルモデルＭ２、吸気弁モデルＭ３、吸気管モデルＭ４、及び吸気弁モデルＭ５の内容については、後に詳述する。
【００７２】なお、本例では、スロットルモデルＭ２、吸気弁モデルＭ３、吸気管モデルＭ４、及び吸気弁モデルＭ５により実際の吸入空気量KLactを求めるが、これとは別に、燃料噴射気筒の前回の吸気行程における吸気弁閉弁時の実スロットル弁開度TAact、同燃料噴射気筒の前回の吸気行程における吸気弁閉弁時の実エンジン回転速度NE、及びテーブル（スロットル弁開度TAacc、エンジン回転速度NE、及び実吸入空気量KLactの関係を予め規定したテーブル）又は計算式を用いて実際の吸入空気量KLactを求めるものであってもよい。
【００７３】＜第２吸入空気モデルＡ４＞第１吸入空気モデルＡ４は、第１吸入空気モデルＡ３が含んでいる空気モデルと同様の空気モデルを構成するスロットルモデルM20、吸気弁モデルM30、吸気管モデルM40、及び吸気弁モデルM50を備えていて、少なくとも電子制御スロットル弁モデルＭ１により予測・推定された予測スロットル弁開度TAestに基いて同燃料噴射気筒の今回の吸気行程における吸気弁閉弁時の吸入空気量（予測吸入空気量）KLfwdを予測・推定する。上記スロットルモデルM20、吸気弁モデルM30、吸気管モデルM40、及び吸気弁モデルM50については、後に詳述する。
【００７４】なお、第１空気モデルＡ３は、燃料噴射気筒の今回の吸気行程における吸気弁閉弁時の予測スロットル弁開度TAest、同燃料噴射気筒の今回の吸気行程における吸気弁閉弁時の実エンジン回転速度NE、及びテーブル（スロットル弁開度TA、エンジン回転速度NE、及び吸入空気量との関係を規定したテーブル）を用いて、今回の吸気行程における吸気弁閉弁時の予測吸入空気量KLfwdを求める（予測する）ように構成されていてもよい。
【００７５】＜目標空燃比設定手段Ａ５＞目標空燃比設定手段は、内燃機関の運転状態であるエンジン回転速度NE、及び目標スロットル弁開度TAt等に基づいて目標空燃比AbyFrefを決定する手段である。この目標空燃比AbyFrefは、例えば、内燃機関の暖機終了後においては、特殊な場合を除き理論空燃比に設定されてよい。
【００７６】＜噴射量決定手段Ａ６＞図５に示した噴射量決定手段Ａ６は、第１吸入空気モデルＡ３により算出された特定気筒の前回の吸気行程における吸気弁閉弁時の実吸入空気量KLact、第２吸入空気モデルＡ４により算出された同特定気筒の今回の吸気行程における吸気弁閉弁時の予測吸入空気量KLfwd、及び目標空燃比設定手段Ａ５により決定された目標空燃比AbyFref等に基いて、同特定気筒の今回の吸気行程に対する正規燃料噴射量fi(k)を決定する手段である。この噴射量決定手段Ａ６は、図６の破線で囲まれた範囲内に詳細を示したように、予測必要燃料量算出手段Ａ51と、補正前燃料噴射量算出手段（燃料挙動逆モデル）Ａ52と、実必要燃料量算出手段Ａ53と、実吸入燃料量算出手段（燃料挙動順モデル）Ａ54と、燃料フィードバック補正量算出手段Ａ55と、燃料噴射量算出手段（正規燃料噴射量算出手段）Ａ56とを備えている。以下、燃料噴射量決定手段Ａ６が備える手段、及びモデルについて、個別に説明を加える。
【００７７】（予測必要燃料量算出手段Ａ51）予測必要燃料量算出手段Ａ51は、第２吸入空気モデルＡ４により求められた前記特定気筒の今回の吸気行程における吸気弁閉弁時の予測吸入空気量KLfwdを、目標空燃比設定手段Ａ５により求められた目標空燃比AbyFrefで除する（KLfwd／AbyFref）ことにより、予測必要燃料量Fcfwdを求める手段である。即ち、この予測必要燃料量Fcfwdは、前記特定気筒の今回の吸気行程において吸入される混合

気の空燃比を目標空燃比AbyFrefとするために、同特定気筒に吸入されるべき燃料の量である。

【００７８】（補正前燃料噴射量算出手段（燃料挙動逆モデル）Ａ52）補正前燃料噴射量算出手段Ａ52は、燃料挙動の逆モデルを用い、噴射した燃料のうち吸気ポートや吸気弁の吸気系に付着することなく筒内に吸入される燃料の量、及び吸気系に付着していた燃料のうち筒内に吸入される燃料の量を考慮して、前記予測必要燃料量Fcfwdの燃料量を燃料噴射気筒に供給するために必要とされる補正前燃料噴射量Fib(k)を算出する手段である。

【００７９】ここで、前記燃料挙動モデルの逆モデルについて説明すると、特定気筒の前回の吸気行程後であって今回の吸気行程直前において、同気筒の吸気ポートに付着していると予測される予測ポート燃料付着量をfwpi(k)、同気筒の吸気弁に付着していると予測される予測バルブ燃料付着量をfwvi(k)、吸気ポートへの燃料付着率をRpi、吸気弁への燃料付着率をRvi、吸気ポートへの燃料残留率をPpi、吸気弁への燃料残留率をPviとするとき、同気筒の今回の吸気行程に対して補正前燃料噴射量Fib(k)の燃料を噴射したとき、同気筒に吸入される燃料量Finは、下記数３で表される。

【００８０】

【数３】$Fin=(1-Rpi-Rvi)\cdot Fib(k)+(1-Ppi)\cdot fwpi(k)+(1-Pvi)\cdot fwvi(k)$

【００８１】従って、特定気筒の今回の吸気行程において予測必要燃料量Fcfwdが同特定気筒に吸入されるためには、上記燃料量Finを予測必要燃料量Fcfwdと等しいと置いて、補正前燃料噴射量Fib(k)を求めればよく、計算結果は下記数４の通りとなる。この数４が、燃料挙動の逆モデルを数式化したものである。

【００８２】

【数４】$Fib(k)=(Fcfwd-(1-Ppi)\cdot fwpi(k)-(1-Pvi)\cdot fwvi(k))/(1-Rpi-Rvi)$

【００８３】補正前燃料噴射量算出手段Ａ52は、予測吸入空気量KLfwdの算出に用いた吸気弁閉弁時の予測吸入空気量KLfwd（又は、同吸気弁閉時の予測スロットル弁開度TAest）、吸気弁閉時の予測されるエンジン回転速度NE（但し、短時間内に変化する量が少ないとして予測吸入空気量KLfwd算出時のエンジン回転速度NEを用いても良い。）、及び吸気弁閉時の予測される吸気弁開閉タイミングVT（但し、短時間内に変化する量が少ないとして予測吸入空気量KLfwd算出時の吸気弁開閉タイミングVTを用いても良い。）等に基いて吸気ポートへの燃料付着率Rpi、吸気弁への燃料付着率Rvi、吸気ポートへの燃料残留率Ppi、及び吸気弁への燃料残留率Pviを求め、これらと上記数４とを用いて補正前燃料噴射量Fib(k)を求める。

【００８４】また、補正前燃料噴射量算出手段Ａ52は、次回のこの特定気筒の吸気行程に対する補正前燃料噴射量Fib(k+1)の演算に備えて、同気筒の今回の吸気行程後であって次回の吸気行程前において同気筒の吸気ポートに付着していると予測される予測ポート燃料付着量をfwpi(k+1)、及び同気筒の今回の吸気行程後であって次回の吸気行程前において同気筒の吸気弁に付着していると予測される予測バルブ燃料付着量をfwvi(k+1)を、下記数５、及び下記数６に基いて求めておく。

【００８５】

【数５】$fwpi(k+1)=Ppi\cdot fwpi(k)+Rpi\cdot Fib(k)$

【００８６】

【数６】$fwvi(k+1)=Pvi\cdot fwvi(k)+Rvi\cdot Fib(k)$

【００８７】（実必要燃料量算出手段Ａ53）実必要燃料量算出手段Ａ53は、第１吸入空気モデルＡ３により求められた前記特定気筒の前回の吸気行程における吸気弁閉弁時の実吸入空気量KLactを、目標空燃比設定手段Ａ５により設定されていた目標空燃比AbyFrefで除する（KLact／AbyFref）ことにより、同特定気筒の前回の吸気行程において空燃比を目標空燃比AbyFrefとするために必要であった燃料量である実必要燃料量Fcactを求める手段である。

【００８８】（実吸入燃料量算出手段（燃料挙動順モデル）Ａ54）実吸入燃料量算出手段Ａ54は、燃料挙動の順モデルを用い、特定気筒の前回の吸気行程に対して実際に噴射した燃料、即ち前回の正規の燃料噴射量fi(k-1)の燃料のうち、吸気系に付着することなく同気筒に吸入された燃料の量、及び吸気系に付着していた燃料のうち同気筒の筒内に吸入された燃料の量を考慮して、同気筒の前回の吸気行程において同気筒の筒内に実際に吸入された燃料量である実吸入燃料量Fcestを求める手段である。

【００８９】ここで、燃料挙動順モデルについて説明すると、特定気筒の前々回の吸気行程後であって前回の吸気行程直前において、同気筒の吸気ポートに付着していたポート燃料付着量をfwp(k-1)、同気筒の吸気弁に付着していたバルブ燃料付着量をfwv(k-1)、吸気ポートへの燃料付着率をRp、吸気弁への燃料付着率をRv、吸気ポートへの燃料残留率をPp、吸気弁への燃料残留率をPvとするとき、同気筒の前回の吸気行程後であって今回の吸気行程直前において、同気筒の吸気ポートに実際に付着していたポート燃料付着量fwp(k)、及び同気筒の吸気弁に実際に付着していたバルブ燃料付着量fwv(k)は、下記数７、及び下記数８により求められる。

【００９０】

【数７】$fwp(k)=Pp\cdot fwp(k-1)+Rp\cdot fi(k-1)$

【００９１】

【数８】$fwv(k)=Pv\cdot fwv(k-1)+Rv\cdot fi(k-1)$

【００９２】従って、特定気筒の前回の吸気行程において、同気筒に実際に吸入された実吸入燃料量Fcestは、下記数９により求められる。上記数７～数９が、燃料挙動の順モデルを表した数式である。

【００９３】

【数９】$Fcest = fi(k-1) - (fwp(k) - fwp(k-1)) - (fwv(k) - fwv(k-1))$

【００９４】なお、実吸入燃料量算出手段Ａ54は、吸気ポートへの燃料付着率Rp、吸気弁への燃料付着率Rv、吸気ポートへの燃料残留率Pp、及び吸気弁への燃料残留率Pvを、前回の吸気行程での吸気弁閉弁時における実際の吸入空気量KLact（又は、同吸気弁閉時における実際のスロットル弁開度）、同吸気弁閉弁時の実際のエンジン回転速度NE（但し、実吸入空気量KLact算出時のエンジン回転速度NEでも良い。）、及び同吸気弁閉時の実際の吸気弁開閉タイミングVT（但し、実吸入空気量KLact算出時の吸気弁開閉タイミングVTを用いても良い。）等に基いて決定し、この決定した付着率、及び残留率と、上記数７～上記数９とに基いて、実吸入燃料量Fcestを気筒毎に算出する。

【００９５】（燃料フィードバック補正量算出手段Ａ55）燃料フィードバック補正量算出手段Ａ55は、特定気筒の前回の吸気行程における燃料の過不足分を表す「実必要燃料量Fcactと実吸入燃料量Fcestの差」、即ち、吸入燃料量誤差Fcerr(k)に基いて、燃料フィードバック補正量Ffb(k)を求める手段である。燃料フィードバック補正量算出手段Ａ55は、本例においては、ＰＩ（比例・積分）コントローラであり、吸入燃料量誤差Fcerr(k)を下記数１０により求めるとともに、燃料フィードバック補正量Ffb(k)を下記数１１、及び下記数１２により求める。下記数１１、及び下記数１２におけるSumFcerrは吸入燃料量誤差Fcerrの積分値である。係数Kp、及び係数Kiは、それぞれ比例定数、及び積分定数である。

【００９６】

【数１０】$Fcerr(k) = Fcact - Fcest$

【００９７】

【数１１】$Ffb(k) = Kp \cdot Fcerr(k) + Ki \cdot SumFcerr(k-1)$

【００９８】

【数１２】$SumFcerr(k) = SumFcerr(k-1) + Fcerr(k)$

【００９９】（燃料噴射量算出手段Ａ56）燃料噴射量算出手段Ａ56は、上記のように求めた補正前燃料噴射量Fib(k)を燃料フィードバック補正量Ffb(k)により補正して、特定気筒の今回の正規燃料噴射量fi(k)を求める手段である。具体的には、上記数１と同じ下記数１３に示したように、補正前燃料噴射量Fib(k)に燃料フィードバック補正量Ffb(k)加えた値を正規燃料噴射量fi(k)として求める。

【０１００】

【数１３】$fi(k) = Fib(k) + Ffb(k)$

【０１０１】ここで、上記噴射量決定手段Ａ６の各手段の計算タイミングについて、特定気筒の各行程と計算タイミングとを図示した図１０を参照しながら説明する。先ず、今回の吸気行程の吸気行程Ａに対する燃料噴射Ａの噴射量fi(k)を決定する場合について考えると、前回の吸気行程Ｂに対する吸気弁閉弁時Ｂよりも後の時点であって今回の吸気行程Ａに対する吸気弁閉弁時Ａよりも前の時点（第３所定時点）にて、第１吸入空気モデルＡ３により実吸入空気量KLactが算出される。今回の吸気行程Ａに対して燃料噴射Ａにより燃料を供給する場合、第３所定時点は同燃料噴射Ａの開始より前の時点であることが好ましい。

【０１０２】次いで、前記第３所定時点より後の時点であって前記気筒の今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の所定時点である第４所定時点にて、実必要燃料量算出手段Ａ53により算出された実吸入空気量KLactに基づいて同気筒の前回の吸気行程Ｂにおいて同気筒に実際に必要とされていた燃料量である実必要燃料量Fcactが算出される。

【０１０３】そして、今回の吸気行程Ａに対する吸気弁閉弁時Ａより前であって前回の吸気行程Ｂに対する正規の燃料噴射量が確定した時点（例えば、前回の正規燃料噴射量fi(k-1)算出時点）よりも後の第５所定時点にて、同気筒の前回の吸気行程において同気筒が実際に吸入した燃料量である実吸入燃料量Fcestが同気筒の前回の吸気行程Ｂに対し実際に噴射された燃料噴射量（正規燃料噴射量）fi(k-1)に基づいて算出される。

【０１０４】この第４所定時点、及び第５所定時点より後の時点であって今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の第６所定時点にて、燃料フィードバック補正量算出手段Ａ55により、前記算出された実必要燃料量Fcactと前記算出された実吸入燃料量Fcestとに基づいて燃料フィードバック補正量Ffb(k)が算出される。

【０１０５】一方、特定気筒の今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の第１所定時点にて、予測吸入空気量算出手段Ａ４により、同気筒の今回の吸気行程Ａでの吸気弁閉弁時Ａの吸入空気量である予測吸入空気量KLfwdが算出される。第１所定時点は、今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の時点であれば、理論上、いつでもよいが、予測吸入空気量KLfwdの予測精度を高めるためには、できるだけ今回の吸気弁閉弁時Ａに近い時点が好ましい。実際には、第１所定時点は、今回の噴射Ａの開始時点の直前が好適である。

【０１０６】また、第１所定時点より後の時点であって前記気筒の今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の第２所定時点にて、補正前燃料噴射量算出手段Ａ52により、前記予測吸入空気量KLfwdに基づいて同気筒の今回の吸気行程Ａに対し噴射すべき仮の噴射量である補正前燃料噴射量Fib(k)が算出される。なお、第１所定時点、及び第２所定時点は、第３～第５所定時点より前の時点であってもよい。

【０１０７】そして、前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の第７所定時点にて、燃料噴射量算出手段Ａ56により、前記算出された補正前燃料噴射量Fib(k)が前記算出された燃料フィードバ

ック補正量Ffb(k)により補正され、同気筒の今回の吸気行程Ａに対し噴射するべき正規の燃料噴射量fi(k)が算出され、同第７所定時点より後の時点であって今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の時点である第８所定時点にて同正規の燃料噴射量fi(k)だけ燃料を噴射するように指示がなされ、これにより燃料噴射Ａが実行される。以上の動作が、一つの気筒の任意の吸気行程と、同一つの気筒の同任意の吸気行程に続く次の吸気行程との間に行われる。

【０１０８】次に、上述した第１吸入空気モデルＡ３、及び第２吸入空気モデルＡ４について詳細に説明する。図５に示したように、第１吸入空気モデルＡ３はモデルＭ２～Ｍ５を備えている。第２吸入空気モデルＡ４は、モデルＭ２～Ｍ５にそれぞれ対応する同一のモデルM20～M50を含んでいて、第１吸入空気モデルＡ３とは使用する（入力する）パラメータのみが異なる。従って、以下、第１吸入空気モデルＡ３を主として説明し、第２吸＊入空気モデルＡ４については第１吸入空気モデルＡ３との相違点についてのみ説明する。

【０１０９】（スロットルモデルＭ２）スロットルモデルＭ２は、スロットル弁４３を通過した空気流量（スロットル通過空気流量）mtを、エネルギー保存則、運動量保存則、質量保存則、及び状態方程式等の物理法則に基づいて得られた下記数１４に基づいて推定するモデルである。下記数１４において、Ct（θt）はスロットル弁開度θt（＝TA）に応じて変化する流量係数、At（θt）はスロットル弁開度θt（＝TA）に応じて変化するスロットル開口面積（吸気管４１の開口面積）、Paはスロットル弁上流圧力（即ち、大気圧）、Pmは吸気管圧力（吸気管内空気圧力）、Taは吸気温度（大気温度）、Tmは吸気管内空気温度、Rは気体定数、及びκは比熱比（以下、κを一定値として扱う。）である。

【０１１０】

【数１４】

$$mt = Ct(\theta t)At(\theta t)Pa\sqrt{\frac{\kappa+1}{2\kappa RTa}}\sqrt{\left(\frac{\kappa}{\kappa+1}\right)^2-\left(\frac{Pm}{Pa}-\frac{1}{\kappa+1}\right)^2}$$

【０１１１】ここで、上記スロットルモデルＭ２を記述した上記数１４の導出過程について説明する。いま、スロットル弁４３の上流の開口断面積をAu、空気密度をρu、空気の流速をvuとし、スロットル弁４３による吸気管４１の開口断面積をAd、そこでの空気密度をρd、スロットル弁４３を通過する空気の流速をvdとすると、スロットル通過空気流量mtは、下記数１５で表される。数１５は質量保存則を記述した式と言える。

【０１１２】

【数１５】mt＝Ad・ρd・vd＝Au・ρu・vu

【０１１３】一方、運動エネルギーは、空気の質量をmとすると、スロットル弁４３の上流でm・vu^2／２であり、スロットル弁４３を通過する場所でm・vd^2／２である。他方、熱エネルギーは、スロットル弁４３の上流でm・Cp・Tuであり、スロットル弁４３を通過する場所でm・Cp・Tdである。従って、エネルギー保存則により、下記数１６が得られる。なお、Tuはスロットルバルブ上流の空気温度、Tdはスロットルバルブ下流の空気温度、Cpは定圧比熱である。

【０１１４】

【数１６】

m・vu^2／２＋m・Cp・Tu＝m・vd^2／２＋m・Cp・Td

【０１１５】ところで、状態方程式は下記数１７、比熱比κは下記数１８、マイヤーの関係は下記数１９で示されるから、数１７～数１９よりCp・Tは下記数２０のように表される。なお、Pは気体の圧力、ρは気体の密度、Tは気体の温度、Rは気体定数、Cvは定容比熱である。

【０１１６】

【数１７】P＝ρ・R・T

【０１１７】

【数１８】κ＝Cp／Cv

【０１１８】

【数１９】Cp＝Cv＋R

【０１１９】

【数２０】Cp・T＝｛κ/(κ−1)｝・(P／ρ)

【０１２０】上記数２０の関係を用いて上記エネルギー保存則に基づく数１６を書換えると、下記数２１が得られる。ここで、Puはスロットル弁４３上流の空気圧力、Pdはスロットル弁４３の下流の空気圧力（即ち、吸気管圧力Pm）である。

【０１２１】

【数２１】vu^2／２＋｛κ/(κ−1)｝・(Pu／ρu)＝vd^2／２＋｛κ/(κ−1)｝・(Pd／ρd)

【０１２２】そして、スロットル弁４３の無限上流を考えると、Au＝∞、vu＝０であるから、エネルギー保存則に基づく上記数２１は下記数２２に書き換えられる。

【０１２３】

【数２２】｛κ/(κ−1)｝・(Pu／ρu)＝vd^2／２＋｛κ/(κ−1)｝・(Pd／ρd)

【０１２４】次に、運動量について記述する。断面積Auの部分に加わる圧力をPu、断面積Adの部分に加わる圧力をPd、断面積Auの部分と断面積Adの部分との間をつなぐ固定された空間の平均圧力をPmeanとすると、下記数２３が得られる。

【０１２５】

【数２３】ρd・vd^2・Ad－ρu・vu^2・Au＝Pu・Au－Pd・Ad＋Pmean・（Ad－Au）

【０１２６】上記数２３で、Au＝∞、vu＝０を考慮すると、下記数２４が得られるので、同数２４と上記数２３

とから下記数２５の運動量に関する関係（運動量保存則に基づく関係）が得られる。

【０１２７】

【数２４】Pmean＝Ｐu

【０１２８】

＊【数２５】$\rho d \cdot vd^2 = Pu - Pd$

【０１２９】従って、上記数１５、上記数２２、及び数２５から、下記数２６が得られる。

【０１３０】

＊【数２６】

$$mt = Ad\sqrt{Pu \cdot \rho u}\sqrt{\left(\frac{Pd}{Pu}+\frac{1}{2}\frac{\kappa-1}{\kappa}\left(1-\frac{Pd}{Pu}\right)\right)\left(1-\frac{Pd}{Pu}\right)}$$

【０１３１】上記数２６において、Puはスロットル弁上流圧力Paであり、Pdは吸気管圧力Pmである。また、状態方程式からρu=M／Vu=Pu／（R・Tu）を上記数２６に代入するとともに、開口断面積Adを開口面積A(θt)と置きなおし、更に流量係数をCt(θt)を加えて上記数２６を整理すると、上記数１４が得られる。

【０１３２】次に、スロットルモデルＭ２におけるスロットル通過空気流量mtの求め方を述べると、上記数１４は下記数２７及び下記数２８により表され、k1をCt(θt)・At(θt)・｛Pa/(R・Ta)$^{1/2}$｝とおき、mtsを吸気弁閉弁時のスロットル通過空気流量とするとき下記数２７は下記数２９に書き換えられる。

【０１３３】

【数２７】mt＝Ct(θt)・At(θt)・｛Pa/(R・Ta)$^{1/2}$｝・Φ（Pm/Pa)

【０１３４】

【数２８】

$$\Phi(Pm/Pa)=\sqrt{\frac{\kappa+1}{2\kappa}}\sqrt{\left(\frac{\kappa}{\kappa+1}\right)^2-\left(\frac{Pm}{Pa}-\frac{1}{\kappa+1}\right)^2}$$

【０１３５】

【数２９】mts＝k1・Φ（Pm/Pa)

【０１３６】また、数２９において、内燃機関１０が定常状態にある場合（スロットル弁開一定のまま推移して吸気弁閉弁に至る場合）のスロットル通過空気流量をmtsTA、及びそのときの吸気管圧力をPmTAとすると、下記数３０が得られるので、数２９及び数３０から係数k1を消去して下記数３１を得ることができる。

【０１３７】

【数３０】mtsTA＝k1・Φ（PmTA/Pa)

【０１３８】

【数３１】

mts＝｛mtsTA／Φ（PmTA/Pa)｝・Φ（Pm/Pa)

【０１３９】上記数３１の右辺における値mtsTAは、スロットル弁開度TAが一定である定常運転状態での吸入空気流量（スロットル通過空気流量）に関する値であり、このような定常運転状態にあってはスロットル通過空気流量mtと筒内吸入空気流量mcとは等しくなる。そこで、スロットルモデルＭ２は、後述する吸気弁モデルＭ３で用いる経験則により得られた式（下記数３２）を用いて現時点から演算周期ΔTtだけ前の時点の筒内吸入空気流量mcを求め、これを値mtsTAとする。なお、この値mtsTA（＝筒内吸入空気流量mc）を求める際の各パラメータ（エンジン回転速度NE、及び吸気弁開閉タイミングVT）は、総べて現時点から演算周期ΔTt前での実際の値を用いる。

【０１４０】また、スロットルモデルＭ２は、スロットル弁開度TA、エンジン回転速度NE、及び吸気弁の開閉タイミングVTと、吸気管圧力Pmとの関係を規定するテーブルMAPPMをＲＯＭ７２内に記憶していて、現時点から演算周期ΔTt前に検出された実際のスロットル弁開度（実スロットル弁開度）TAact(k-1)、現時点から演算周期ΔTt前の実際のエンジン回転速度NE、及び現時点から演算周期ΔTt前の実際の吸気弁の開閉タイミングVTと、前記テーブルMAPPMとに基づいて上記数３１の右辺における吸気管圧力PmTA（＝MAPPM(TAact(k-1),NE,VT)）を求める。

【０１４１】更に、スロットルモデルＭ２は、値Pm/Paと値Φ(Pm/Pa)との関係を規定するテーブルMAPΦを記憶していて、前記吸気管圧力PmTAをスロットル弁上流圧力Paで除した値（PmTA/Pa）と、前記テーブルMAPΦとから、上記数３１の右辺における値Φ(PmTA/Pa)（＝MAPΦ(PmTA/Pa)）を求める。同様にして、スロットルモデルＭ２は、後述する吸気管モデルＭ４が既に求めている前回の吸気管圧力Pm(k-1)をスロットル弁上流圧力Paで除した値（Pm(k-1)/Pa）と、前記テーブルMAPΦとから、上記数３１の右辺における値Φ(Pm/Pa)（＝MAPΦ(Pm(k-1)/Pa)）を求める。以上により、上記数３１の右辺の各因数が求められるので、これらを掛け合わせることにより、スロットル通過空気流量mts(＝mt(k-1))が求められる。

【０１４２】（吸気弁モデルＭ３）吸気弁モデルＭ３は、吸気管圧力Pm、吸気管内温度Tm、及び吸気温度THA等から筒内吸入空気流量mcを推定するモデルである。吸気弁閉弁時の気筒内圧力は吸気弁３２の上流の圧力、即ち吸気弁閉弁時の吸気管圧力Pmとみなすことができるので、筒内吸入空気流量mcは吸気弁閉弁時の吸気管圧力Pmに比例する。そこで、吸気弁モデルＭ３は筒内吸入空気流量mcを、経験則に基づく下記数３２にしたがって求める。

【０１４３】

【数３２】mc＝（THA/Tm）・（c・Pm－d)

【０１４４】数３２において、値cは比例係数、値dは筒内に残存していた既燃ガス量に対応する量である。吸気

弁モデルＭ３は、エンジン回転速度NE、及び吸気弁の開閉タイミングVTと、比例係数c、及び既燃ガス量dとの関係をそれぞれ規定するテーブルMAPC、及びMAPDをＲＯＭ７２内に格納していて、現時点から演算周期ΔTt前の実際のエンジン回転速度NEと、現時点から演算周期ΔTt前の実際の吸気弁の開閉タイミングVTと、前記格納しているテーブルとから比例係数c（＝MAPC(NE,VT)）、及び既燃ガス量d（＝MAPD(NE,VT)）を求める。また、吸気弁モデルＭ３は、演算時点にて、後述する吸気管モデルＭ４により既に推定されている直前（最新）の吸気弁閉弁時の吸気管圧力Pm(＝Pm(k-1))と直前の吸気管内空気温度Tm(＝Tm(k-1))とを上記数３２に適用し、吸気弁閉弁時の筒内吸入空気流量mc（＝mc(k-1)）を推定する。

【０１４５】（吸気管モデルＭ４）吸気管モデルＭ４は、質量保存則とエネルギー保存則とにそれぞれ基づいた下記数３３及び下記数３４、スロットル通過空気流量mt、スロットル通過空気温度（即ち、吸入空気温度THA）Ta、及び吸気管から流出する空気流量mc（即ち、筒内吸入空気流量）から、吸気管圧力Pm、及び吸気管内空気温度Tmを求めるモデルである。なお、下記数３３、及び下記数３４において、Vmはスロットル弁４３から吸気弁３２までの吸気管４１（以下、単に「吸気管部」と称呼する。）の容積である。

【０１４６】

【数３３】$d(Pm/Tm)/dt=(R/Vm)\cdot(mt-mc)$

【０１４７】

【数３４】$dPm/dt=\kappa\cdot(R/Vm)\cdot(mt\cdot Ta-mc\cdot Tm)$

【０１４８】吸気管モデルＭ４は、上記数３３、及び上記数３４の右辺におけるスロットル通過空気流量mt（＝mt(k-1)）をスロットルモデルＭ２から取得し、筒内吸入空気流量mc（＝mc(k-1)）を吸気弁モデルＭ３から取得する。そして、数３３及び数３４に基づく計算を行って最新の吸気管圧力Pm(＝Pm(k))、及び吸気管内空気温度Tm(＝Tm(k))を推定する。

【０１４９】ここで、上記吸気管モデルＭ４を記述した数３３及び数３４の導出過程について説明する。いま、吸気管部の総空気量をMとすると、総空気量Mの時間的変化は、吸気管部に流入する空気量に相当するスロットル通過空気流量mtと同吸気管部から流出する空気量に相当する筒内吸入空気流量mcの差であるから、質量保存則に基づく下記数３５が得られる。

【０１５０】

【数３５】$dM/dt=mt-mc$

【０１５１】また、状態方程式は下記数３６となるから、上記数３５と下記数３６とから総空気量Mを消去することにより、質量保存則に基づく上記数３３が得られる。

【０１５２】

【数３６】$Pm\cdot Vm=M\cdot R\cdot Tm$

【０１５３】次に、吸気管部に関するエネルギー保存則について検討すると、この場合、吸気管部の容積Vmは変化せず、また、エネルギーの殆どが温度上昇に寄与する（運動エネルギーは無視し得る）と考えられる。従って、吸気管部の空気のエネルギーM·Cv·Tmの時間的変化量は、同吸気管部に流入する空気のエネルギーCp·mt·Taと同吸気管部から流出する空気のエネルギーCp·mc·Tmとの差に等しいので、下記数３７が得られる。

【０１５４】

【数３７】$d(M\cdot Cv\cdot Tm)/dt=Cp\cdot mt\cdot Ta-Cp\cdot mc\cdot Tm$

【０１５５】この数３７を、上記数１８（$\kappa=Cp/Cv$）と、上記数３６（$Pm\cdot Vm=M\cdot R\cdot Tm$）とを用いて変形することにより、上記数３４が得られる。

【０１５６】（吸気弁モデルＭ５）吸気弁モデルＭ５は、上記吸気弁モデルＭ３と同様のモデルを含んでいて、ここでは吸気管モデルＭ４が算出した最新の吸気管圧力Pm(＝Pm(k))、及び吸気管内空気温度Tm(＝Tm(k))と、現時点のエンジン回転速度NEと、現時点の吸気弁の開閉タイミングVTと、前記マップMAPCと、前記マップMAPDと、上記経験則に基づく数３２（mc＝（THA/Tm）·（c·Pm－d）とを用いて最新の筒内吸入空気流量mc（＝mc(k)）を求める。そして、吸気弁モデルＭ５は、求めた筒内吸入空気流量mcに、エンジン回転速度NEから算出された前回の吸気行程Ｂにおいて吸気弁３２が開弁してから閉弁するまでの時間）Tintを乗じることにより吸入空気量KLactを求める。なお、吸気弁モデルＭ５は、このような演算を各気筒毎に行うとともに、各気筒別に同各気筒の吸気弁閉弁時直後において求められた吸入空気量KLactを、同各気筒の実際の吸入空気量（実吸入空気量）KLact0として噴射量決定手段Ａ６に出力する。

【０１５７】以上、説明したように、第１吸入空気モデルＡ３は、特定の気筒の前回の吸気行程Ｂでの吸気弁閉弁時Ｂより後の時点であって同気筒の今回の（次の）吸気行程Ａに対する吸気弁閉弁時Ａより前の第３所定時点（実際には、吸気行程Ｂに対する吸気弁閉弁直後の時点）にて同気筒の前回の吸気行程Ｂでの吸気弁閉弁時Ｂの実際の吸入空気量である実吸入空気量KLactを、運転状態量取得手段Ａ２であるスロットルポジションセンサ７６により取得された実際の運転状態量、即ち実スロットル弁開度TAactとモデルＭ２～Ｍ５からなる内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する。

【０１５８】<第２吸入空気モデルＡ４>第２吸入空気モデル（第２空気モデル）Ａ４は、内燃機関の吸気系における空気の挙動をモデル化した第１吸入空気モデルの空気モデルと同様なモデルであって、スロットルモデルM20、吸気弁モデルM30、吸気管モデルM40、及び吸気弁モデルM50を備えている。この第２吸入空気モデルＡ４は、今回の吸気行程Ａの吸気弁閉弁時Ａの吸入空気量KLfwdを予測するため、第１吸入空気モデルＡ３が実スロットル弁開度TAactを入力するのに対し、上述した電

子制御スロットル弁モデルＭ１により推定される予測スロットル弁開度TAestを入力する点で、同第１吸入空気モデルＡ３と異なる。

【０１５９】（スロットルモデルM20）スロットルモデルM20は、上記数３１に基き、将来の（所定時間、例えば遅延時間TDだけ後の）時点におけるスロットル通過空気流量mtを予測する。この場合においても、上記数３１の右辺のmtsTAは、筒内吸入空気流量mcと等しいと考えられるので、後述する吸気弁モデルM30で用いる上記数３２により同値mtsTAを求める。なお、値mtsTAを求める際の各パラメータ（エンジン回転速度NE、及び吸気弁開閉タイミング）は、便宜上、現時点での値とする。

【０１６０】また、スロットルモデルM20は、燃料噴射開始時期直前（BTDC９０°CA）から吸気弁閉弁時までの時間をエンジン回転速度NEから求め、この時間と略一致する遅延時間後の予測スロットル弁開度TAestをＲＡＭ７２から読み出し、それを予測スロットル弁開度TAest(k-1)とする。そして、この予測スロットル弁開度TAest(k-1)、現時点から演算周期ΔTtだけ前の実際のエンジン回転速度NE、及び現時点から演算周期ΔTt前の実際の吸気弁の開閉タイミングVTと、前記テーブルMAPPMとに基づいて上記数３１の右辺における吸気管圧力PmTA（＝MAPPM(TAest(k-1),NE,VT)）を求める。

【０１６１】更に、スロットルモデルM20は、前記吸気管圧力PmTAをスロットル弁上流圧力Paで除した値（PmTA/Pa）と、前記テーブルMAPΦとから、上記数３１の右辺における値Φ(PmTA/Pa)（＝MAPΦ(PmTA/Pa)）を求める。同様にして、スロットルモデルM20は、後述する吸気管モデルM40が既に求めている前回の吸気管圧力Pm(k-1)をスロットル弁上流圧力Paで除した値（Pm(k-1)/Pa）と、前記テーブルMAPΦとから、上記数３１の右辺における値Φ(Pm/Pa)（＝MAPΦ(Pm(k-1)/Pa)）を求める。以上により、上記数３１の右辺の各因数が求められるので、これらを掛け合わせることにより、予測スロットル通過空気流量mts(＝mt(k-1))が求められる。

【０１６２】（吸気弁モデルM30）吸気弁モデルM30は、筒内吸入空気流量mcを上記経験則に基づく数３２にしたがって求める。具体的には、比例係数cを実際のエンジン回転速度NEと、実際の吸気弁の開閉タイミングVTと、MAPC(NE,VT)とから求め、既燃ガス量dを、実際のエンジン回転速度NEと、実際の吸気弁の開閉タイミングVTと、MAPD(NE,VT)とから求める。また、吸気弁モデルM30は、演算時点にて、後述する吸気管モデルM40により既に推定されている最新の吸気管圧力Pm(＝Pm(k-1))と最新の吸気管内空気温度Tm(＝Tm(k-1))とを上記数３２に適用し、筒内吸入空気流量mc（＝mc(k-1)）を推定する。

【０１６３】（吸気管モデルM40）吸気管モデルM40は、上記数３１及び上記数３２、スロットルモデルM20により求められたスロットル通過空気流量mt、実際のスロットル通過空気温度（即ち、吸入空気温度THA）Ta、及び吸気弁モデルM30により求められた吸気管から流出する空気流量mc（即ち、筒内吸入空気流量）から、吸気管圧力Pm、及び吸気管内空気温度Tmを求める。

【０１６４】（吸気弁モデルM50）吸気弁モデルM50は、入力するパラメータが異なる点を除き、上記吸気弁モデルM30と同様のモデルであり、吸気管モデルM40が算出した最新の吸気管圧力Pm(＝Pm(k))、及び吸気管内空気温度Tm(＝Tm(k))と、上記経験則に基づく数３２（mc＝(THA/Tm)・(c・Pm－d)）を用いて筒内吸入空気流量mc（＝mc(k)）を求める。そして、吸気弁モデルM50は、求めた筒内吸入空気流量mcに、エンジン回転速度NEから算出される吸気行程に要する時間（吸気弁３２が開弁してから閉弁するまでの時間）Tintを乗じることにより予測吸入空気量KLfwdを求める。吸気弁モデルM50は、このような演算を各気筒毎に所定時間の経過毎に行う。

【０１６５】このように、第２空気モデルＡ４は、予測吸入空気量KLfwdを所定時間の経過毎に更新するが、燃料噴射開始時期直前（BTDC９０°CA）から吸気弁閉弁時までの時間と略一致する遅延時間後の予測スロットル弁開度TAestに基いて予測吸入空気量KLfwdを計算すること、及び同燃料噴射開始時期直前の時点での予測吸入空気量KLfwdに基いて補正前燃料噴射量Fibが計算されことから、同第２空気モデルＡ４は、ある気筒の吸気行程に対する吸気弁閉弁時の予測スロットル弁開度TAestに基いて、吸入空気量を実質的に予測する予測吸入空気量算出手段を構成していることになる。

【０１６６】即ち、第２吸入空気モデルＡ４は、特定の気筒の今回の吸気行程Ａに対する吸気弁閉弁時Ａより前の第１所定時点（本例においては、同気筒の今回の吸気行程に対する燃料噴射開始（BTDC７５°CA)前の所定のタイミング、具体的にはBTDC９０°CA）にて同気筒の今回の吸気行程Ａでの吸気弁閉弁時Ａの吸入空気量である予測吸入空気量KLfwdを、運転状態量予測手段である電子制御スロットル弁モデルＭ１により予測された同第１所定時点より先の時点における運転状態量、即ち、今回の吸気行程Ａの吸気弁閉弁時Ａ近傍の時点の予測スロットル弁開度TAestとモデルM20～M50とに基づいて算出するのである。以上、図５及び図６に示した各モデル、及び各手段により、正規燃料噴射量fiが計算される。

【０１６７】次に、電気制御装置７０の実際の作動について、図１１～図１８に示したフローチャートを参照しながら説明する。

【０１６８】（目標スロットル弁開度、及び推定スロットル弁開度の計算）ＣＰＵ７１は、図１１にフローチャートにより示したルーチンを演算周期ΔTt（ここでは、８msec）の経過毎に実行することにより、上記電子制御スロットル弁ロジックＡ１、及び電子制御スロットル弁モデルＭ１の機能を達成する。具体的に述べると、ＣＰＵ７１は所定のタイミングにてステップ１１００から処

理を開始し、ステップ１１０５に進んで変数ｉに「０」を設定し、ステップ１１１０に進んで変数ｉが遅延回数ntdlyと等しいか否かを判定する。この遅延回数ntdlyは、遅延時間TDを演算周期ΔTtで除した値である。

【０１６９】この時点で変数ｉは「０」であるから、ＣＰＵ７１はステップ１１１０にて「Ｎｏ」と判定し、ステップ１１１５に進んで暫定目標スロットル弁開度TAt(i)に暫定目標スロットル弁開度TAt(i+1)の値を格納するとともに、続くステップ１１２０にて予測スロットル弁開度TAest(i)に予測スロットル弁開度TAest(i+1)の値を格納する。以上の処理により、暫定目標スロットル弁開度TAt(0)に暫定目標スロットル弁開度TAt(1)の値が格納され、予測スロットル弁開度TAest(0)に予測スロットル弁開度TAest(1)の値が格納される。

【０１７０】次いで、ＣＰＵ７１は、ステップ１１２５にて変数ｉの値を「１」だけ増大してステップ１１１０にもどる。そして変数ｉの値が今回の遅延回数ntdlyより小さければ、再びステップ１１１５～１１２５を実行する。即ち、ステップ１１１５～１１２５は、変数ｉの値が遅延回数ntdlyと等しくなるまで繰り返し実行される。これにより、暫定目標スロットル弁開度TAt(i+1)の値が暫定目標スロットル弁開度TAt(i)に順次シフトされ、予測スロットル弁開度TAest(i+1)の値が予測スロットル弁開度TAest(i)に順次シフトされて行く。

【０１７１】前述のステップ１１２５が繰り返されることにより変数ｉの値が遅延回数ntdlyと等しくなると、ＣＰＵ７１はステップ１１１０にて「Ｙｅｓ」と判定してステップ１１３０に進み、同ステップ１１３０にて現時点の実際のアクセル操作量Accpと、図７に示したテーブルとに基づいて今回の暫定目標スロットル弁開度TAaccを求め、これを暫定目標スロットル弁開度TAt(ntdly)に格納する。

【０１７２】次に、ＣＰＵ７１はステップ１１３５に進み、同ステップ１１３５にて前回の予測（推定）スロットル弁開度TAest(ntdly)と、今回の暫定目標スロットル弁開度TAaccと、上記数２（の右辺）に基づくステップ１１３５内に記載した式とに応じて今回の予測スロットル弁開度TAest(ntdly)を算出する。そして、ステップ１１４０にて目標スロットル弁開度TAtに暫定目標スロットル弁開度TAt(0)の値を設定するとともに、予測スロットル弁開度TAestに最新の予測スロットル弁開度TAest(ntdly)を格納し、ステップ１１９５に進んで本ルーチンを一旦終了する。

【０１７３】以上のように、目標スロットル弁開度TAtに関するメモリにおいては、本ルーチンが実行される毎にメモリの内容が一つずつシフトされて行き、暫定目標スロットル弁開度TAt(0)に格納された値が、電子制御スロットル弁ロジックＡ１によってスロットル弁アクチュエータ４３ａに出力される目標スロットル弁開度TAtとして設定される。即ち、今回の本ルーチンの実行により暫定目標スロットル弁開度TAt(ntdly)に格納された値は、今後において本ルーチンが遅延回数ntdlyだけ繰り返されたときにTAt(0)に格納され、目標スロットル弁開度TAtとなる。また、予測スロットル弁開度TAestに関するメモリにおいては、同メモリ内のTAest(m)に現時点から所定時間(m*ΔTt)経過後の予測スロットル弁開度TAestが格納されて行く。この場合の値mは、１～ntdlyの整数である。

【０１７４】（予測吸入空気量KLfwdの計算）ＣＰＵ７１は、所定の演算周期ΔTt（８msec）の経過毎に図１２に示した予測吸入空気量計算ルーチンを実行することで、第２吸入空気モデルＡ４（スロットルモデルM20、吸気弁モデルM30、吸気管モデルM40、及び吸気弁モデルM50）の機能を達成するようになっている。具体的に説明すると、所定のタイミングになったとき、ＣＰＵ７１はステップ１２００から処理を開始し、ステップ１２０５に進んで上記スロットルモデルM20（上記数３１に基くステップ１２０５内に示した式）によりスロットル通過空気流量mt(k-1)を求めるため、図１３のフローチャートに示したステップ１３００に進む。なお、スロットル通過空気流量mtの括弧内の変数がkではなくk-1となっているのは、このスロットル通過空気流量mt(k-1)が演算周期ΔTt前の各種値を用いて求められた値であることを意味していて、この変数k，k-1の意味は以下に述べる他の値についても同様である。

【０１７５】ステップ１３００に進んだＣＰＵ７１は、ステップ１３０５に進んで上記数３２の係数c（＝c(k-1)）を、上記テーブルMAPCと、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTとから求める。また、同様に値d（＝d(k-1)）を、上記テーブルMAPDと、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTとから求める。

【０１７６】次いで、ＣＰＵ７１はステップ１３１０に進んで燃料噴射開始時期直前（BTDC９０°CA）から吸気弁閉弁時までの時間をエンジン回転速度NEから求め、この時間と略一致する遅延時間後の予測スロットル弁開度TAestをＲＡＭ７３から読み出し、それを予測スロットル弁開度TAest(k-1)とし、その予測スロットル弁開度TAest(k-1)、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTと、上記テーブルMAPPMと、から吸気管圧力PmTAを求め、ステップ１３１５に進んで上記数３２に基づき、スロットル通過空気流量mtsTAを求める。なお、ステップ１３１５において用いるスロットル通過空気温度Taは吸入空気温度センサが検出する吸入空気温度THAを用い、吸気管内空気温度Tm(k-1)は、前回の本ルーチン実行時における後述するステップ１２１５にて求められた値を用いる。

【０１７７】次いで、ＣＰＵ７１はステップ１３２０に進み、同ステップ１３２０にて値Φ(PmTA/Pa)を上記テーブルMAPΦと上記ステップ１３１０にて求めた吸気管圧力PmTAをスロットル弁上流圧力（大気圧センサ６３が検出する大気圧）Paで除した値（PmTA/Pa）とから求める。また、続くステップ１３２５にて、前回の本ルーチン実行時における後述するステップ１２１５にて求められた吸気管圧力Pm(k-1)をスロットル弁上流圧力Paで除した値（Pm(k-1)/Pa）と、上記テーブルMAPΦとから値Φ(Pm/Pa)を求め、続くステップ１３３０にて上記ステップ１３１５，１３２０、及びステップ１３２５にてそれぞれ求めた値と、スロットルモデルを表すステップ１３３０内に示した式とに基づいてスロットル通過空気流量mt(k-1)を求め、ステップ１３９５を経由して図１２のステップ１２１０に進む。

【０１７８】ＣＰＵ７１は、ステップ１２１０にて上記吸気弁モデルＭ３を表す数３２を用いて筒内吸入空気流量mc(k-1)を求める。このとき、係数c、及び値dとして、上記ステップ１３０５にて求めた値を使用する。また、吸気管圧力Pm(k-1)、及び吸気管内空気温度Tm(k-1)は、前回の本ルーチン実行時における後述するステップ１２１５にて求められた値を用い、スロットル通過空気温度Taは吸入空気温度センサが検出する吸入空気温度THAを用いる。

【０１７９】次に、ＣＰＵ７１はステップ１２１５に進み、上記吸気管モデルＭ４を表す数３３、及び数３４を離散化したステップ１２１５に示した式（差分方程式）と、上記ステップ１２０５、及びステップ１２１０にてそれぞれ求めたスロットル通過空気流量mt(k-1)、及びmc(k-1)とに基づいて、今回の吸気管圧力Pm(k)と、同吸気管圧力Pm(k)を今回の吸気管内空気温度Tm(k)にて除した値｛Pm/Tm｝(k)とを求める。なお、Δｔは吸気管モデルM40で使用される離散間隔を示し、計算時間をΔTt（＝８msec）、前回(k-1)の燃料噴射開始時期から吸気弁閉弁時までの時間をt_0、今回(k)の燃料噴射開始時期から吸気弁閉弁時までの時間をt_1とするとき、Δｔ＝ΔTt＋（t_1－t_0）で表される時間である。

【０１８０】次いで、ＣＰＵ７１はステップ１２２０に進み、同ステップ１２２０に示した上記吸気弁モデルＭ50を表す式に基づいて今回の筒内吸入空気流量mc(k)を求める。具体的に述べると、ＣＰＵ７１はステップ１２２０に進んだとき、図１４に示したステップ１４００に進み、次のステップ１４０５にて係数c(k)をエンジン回転速度NEと吸気弁の開閉タイミングVTとMAPCとにより求め（c(k)＝MAPC(NE,VT)）、続くステップ１４１０にて値d(k)をエンジン回転速度NEと吸気弁の開閉タイミングVTとMAPDとにより求める（d(k)＝MAPD(NE,VT)）。このときのエンジン回転速度NE、及び吸気弁の開閉タイミングVTは、現時点での値を用いる。そして、ＣＰＵ７１は、ステップ１４１５に進んで、上記ステップ１２１５にて求められた今回の吸気管圧力Pm(k)、及び同ステップ１２１５にて求められた今回の吸気管内空気温度Tm(k)、ステップ１４０５にて求められた係数c(K)、及びステップ１４１０にて求められた値d(k)を用いて、今回の筒内吸入空気流量mc(k)を算出し、ステップ１４９５を経由して図１２のステップ１２２５に進む。

【０１８１】ＣＰＵ７１はステップ１２２５にて、現時点でのエンジン回転速度NEと、インテークカムシャフトのカムプロフィールで決定されている吸気弁開弁角とから吸気弁開弁時間（吸気弁が開弁してから閉弁するまでの時間）Tintを計算し、続くステップ１２３０にて上記今回の筒内吸入空気流量mc(k)に吸気弁開弁時間Tintを乗じて予測吸入空気量KLfwdを算出し、ステップ１２９５に進んで本ルーチンを一旦終了する。以上により、予測吸入空気量KLfwdが求められる。

【０１８２】（実吸入空気量KLact）ＣＰＵ７１は、所定の演算周期ΔTt（８msec）の経過毎に図１５に示した実吸入空気量計算ルーチンを実行することで、第１吸入空気モデルＡ３（スロットルモデルＭ２、吸気弁モデルＭ３、吸気管モデルＭ４、及び吸気弁モデルＭ５）の機能を達成するようになっている。このルーチンは、先に説明した図１２の予測吸入空気量計算ルーチンと同様な処理を行って、実吸入空気量KLactを求める。その際、ＣＰＵ７１は、図１３、及び図１４に示したルーチンとそれぞれ同様な処理を行うための図１６、及び図１７に示したルーチンを実行する。なお、スロットル通過空気流量等の各量を図１２～図１４の各量と区別するため、同各量の名称末尾に文字「ａ」を追加している。

【０１８３】図１５～図１７に示したルーチンと、図１２～図１４に示したルーチンとの主たる相違点を簡単に説明すると、ＣＰＵ７１はステップ１５０５にて上記スロットルモデルＭ２（上記数３１に基くステップ１５０５内に示した式）によりスロットル通過空気流量mta(k-1)を求める。

【０１８４】このとき、ＣＰＵ７１は図１６に示したルーチンを実行し、ステップ１６０５にて上記数３２の係数c（＝ca(k-1)）を、上記テーブルMAPCと、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTとから求める。また、同様に値d（＝da(k-1)）を、上記テーブルMAPDと、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTとから求める。

【０１８５】次いで、ＣＰＵ７１はステップ１６１０に進んで吸気管圧力PmTAaを上記テーブルMAPPMと、現時点から演算周期ΔTt前に検出された実スロットル弁開度TAact(K-1)、現時点より演算周期ΔTt前のエンジン回転速度NE、及び現時点より演算周期ΔTt前の吸気弁の開閉タイミングVTとから求め、ステップ１６１５に進んで上記数３２に基づき、スロットル通過空気流量mtsTAaを求め

る。なお、ステップ１６１５において用いるスロットル通過空気温度Taは吸入空気温度センサが検出する吸入空気温度THAを用い、吸気管内空気温度Tma(k-1)は、前回の本ルーチン実行時における後述するステップ１５１５にて求められた値を用いる。

【０１８６】次いで、ＣＰＵ７１はステップ１６２０に進み、同ステップ１６２０にて値Φ(PmTAa/Pa)を上記吸気管圧力PmTAaをスロットル弁上流圧力Paで除した値（PmTAa/Pa）と上記MAPΦとから求める。また、続くステップ１６２５にて、前回の本ルーチン実行時における後述するステップ１５１５にて求められた吸気管圧力Pma(k-1)をスロットル弁上流圧力Paで除した値（Pma(k-1)/Pa）と、上記テーブルMAPΦとから値Φ(Pma/Pa)を求め、続くステップ１６３０にて上記ステップ１６１５，１６２０、及びステップ１６２５にてそれぞれ求めた値と、スロットルモデルを表すステップ１６３０内に示した式とに基づいてスロットル通過空気流量mta(k-1)を求め、ステップ１６９５を経由して図１５のステップ１５１０に進む。

【０１８７】ＣＰＵ７１は、ステップ１５１０にて上記吸気弁モデルM30を表す数３２を用いて筒内吸入空気流量mca(k-1)を求める。このとき、係数ca、及び値daとして、上記ステップ１６０５にて求めた値を使用する。また、吸気管圧力Pma(k-1)、及び吸気管内空気温度Tma(k-1)は前回の本ルーチン実行時における後述するステップ１５１５にて求められた値を用い、スロットル通過空気温度Taは吸入空気温度センサが検出する吸入空気温度THAを用いる。

【０１８８】次に、ＣＰＵ７１はステップ１５１５に進み、スロットル通過空気流量mta(k-1)、及び筒内吸入空気流量mca(k-1)とに基づいて、今回の吸気管圧力Pma(k)と、同吸気管圧力Pma(k)を今回の吸気管内空気温度Tma(k)にて除した値 {Pma/Tma} (k)とを求める。次いで、ＣＰＵ７１はステップ１５２０に進み、同ステップ１５２０に示した上記吸気弁モデルM50を表す式に基づいて今回の筒内吸入空気流量mca(k)を求める。この場合、ＣＰＵ７１は、図１７に示したステップ１７０５にて係数ca(k)をエンジン回転速度NEと吸気弁の開閉タイミングVTとMAPCとにより求め（ca(k)＝MAPC(NE,VT)）、続くステップ１６１０にて値da(k)をエンジン回転速度NEと吸気弁の開閉タイミングVTとMAPDとにより求める（da(k)＝MAPD(NE,VT)）。ここで使用するエンジン回転速度NE、及び吸気弁の開閉タイミングVTは、現時点での値を用いる。そして、ＣＰＵ７１は、ステップ１７１５に進んで、今回の吸気管圧力Pma(k)、今回の吸気管内空気温度Tma(k)、係数ca(K)、及び値da(k)を用いて、今回の筒内吸入空気流量mca(k)を算出し、ステップ１７９５を経由して図１５のステップ１５２５に進む。

【０１８９】ＣＰＵ７１はステップ１５２５にて、現時点でのエンジン回転速度NEと、インテークカムシャフトのカムプロフィールで決定されている吸気弁開弁角とから吸気弁開弁時間Tintを計算し、続くステップ１５３０にて上記今回の筒内吸入空気流量mca(k)に吸気弁開弁時間Tintを乗じて実吸入空気量KLactを算出する。次いで、ＣＰＵ７１はステップ１５３５に進み、現時点が吸気弁が開弁状態から閉弁状態に変化した直後であるか否かを判定し、直後であればステップ１５４０にて実吸入空気量KLactを吸気弁閉弁時の実吸入空気量KLact0として格納し、ステップ１５９５に進んで本ルーチンを一旦終了する。また、ＣＰＵ７１は、ステップ１５３５にて「Ｎｏ」と判定されるとき、直接ステップ１５９５に進んで本ルーチンを一旦終了する。以上により、実スロットル弁開度TAactに基いて吸気弁閉弁時の実吸入空気量KLact0が求められる。なお、実吸入空気量KLact0は、各気筒毎に求められ、各気筒に対応付けられた状態でＲＡＭ７３に格納される。

【０１９０】（噴射実行ルーチン）次に、電気制御装置７０が、実際に噴射を行うために実行するルーチンについて、同ルーチンをフローチャートにより示した図１８を参照して説明すると、ＣＰＵ７１は各気筒のクランク角度がBTDC９０°ＣＡになる毎に、各気筒毎に同図１８に示したルーチンを実行するようになっている。

【０１９１】従って、特定の（任意の）気筒のクランク角度がBTDC９０°ＣＡになると、ＣＰＵ７１はステップ１８００から処理を開始し、続くステップ１８０５にて予測吸入空気量KLfwdを目標空燃比AbyFrefで除することにより（Fcfwd=KLfwd/AbyFref）予測必要燃料量Fcfwdを求める。次いで、ＣＰＵ７１は、ステップ１８１０にて、この特定気筒の今回の吸気行程における吸気弁閉時の予測スロットル弁開度TAest、実際のエンジン回転速度NE、及び実際の吸気弁の開閉タイミングVTとに基いて吸気ポートへの燃料付着率Rpi、吸気弁への燃料付着率Rvi、吸気ポートへの燃料残留率Ppi、及び吸気弁への燃料残留率Pviを求めるとともに、上記数４の右辺（ステップ１８１０中に記載した式）で表される燃料挙動の逆モデルにしたがって補正前燃料噴射量Fib(k)を求める。

【０１９２】次に、ＣＰＵ７１はステップ１８１５に進み、特定気筒の今回の吸気行程に対して前記ステップ１８１０にて求めた補正前燃料噴射量Fib(k)を同特定気筒に対し噴射すると仮定し、同今回の吸気行程後であって次回の吸気行程直前において同気筒の吸気ポートに付着していると予測される予測ポート燃料付着量fwpi(k+1)、及び同気筒の今回の吸気行程後であって次回の吸気行程直前において同気筒の吸気弁に付着していると予測される予測バルブ燃料付着量fwvi(k+1)を、上記数５、及び上記数６（ステップ１８１５中に記載した式）に基いて求める。

【０１９３】次いで、ＣＰＵ７１はステップ１８２０に進み、同ステップ１８２０にて前記特定気筒の前回の吸気行程における吸気弁閉弁時の実吸入空気量KLact0をＲ

ＡＭ７３から読み出し、同実吸入空気量KLact0を目標空燃比設定手段Ａ５により求められた目標空燃比AbyFrefで除する（KLact0／AbyFref）ことにより、同特定気筒の前回の吸気行程において空燃比を目標空燃比AbyFrefとするために必要であった燃料量である実必要燃料量Fcactを求める。

【０１９４】次に、ＣＰＵ７１はステップ１８２５にて同ステップ中に記載した上記数５、及び上記数６に類似した式に従って、前回の吸気行程（特定の気筒の任意の吸気行程）に対し実際に噴射された燃料噴射量fi(k-1)、同気筒の前々回の吸気行程（同任意の吸気行程の一回前の吸気行程）後であって前回の吸気行程前（同任意の吸気行程前）における実際のポート燃料付着量（実ポート燃料付着量）fwp(k-1)、及び実際のバルブ燃料付着量（実バルブ燃料付着量）fwv(k-1)に基づいて、同気筒の前回の吸気行程（同任意の吸気行程）後であって今回の吸気行程（同任意の吸気行程の次の（一回後の）吸気行程）前における実ポート燃料付着量fwp(k)、及び実バルブ燃料付着量fwv(k)を算出する。

【０１９５】次に、ＣＰＵ７１はステップ１８３０に進み、同ステップ中に記載した式に基いて特定気筒の前回の吸気行程における実吸入燃料量Fcestを算出する。なお、ステップ１８３０では、各燃料付着量の増加分を正規燃料噴射量fi(k-1)から減ずることにより、実吸入燃料量Fcestを求めるようにしている。次いで、ＣＰＵ７１はステップ１８３５に進み、前回の吸気行程に対する実必要燃料量Fcactから実吸入燃料量Fcestを減ずることにより、前回の吸気行程における燃料量の過不足分を表す筒内吸入燃料量誤差Fcerr(k)を求め（上記数１０を参照。）、続くステップ１８４０にて同ステップ内に記載した式に基いて燃料フィードバック補正量Ffb(k)を求める（上記数１１を参照）。なお、同ステップ内に記載した式において、SumFcerrは上記数１２に基いて求められる吸入燃料量誤差Fcerrの積分値であり、後述するステップ１８５５にて算出される。係数Kp、及び係数Kiは、それぞれ予め設定されている比例定数、及び積分定数である。即ち、ステップ１８５５は燃料フィードバック補正量Ffbを求めるためのフィードバックコントローラ（比例・積分制御器）の一部を構成している。

【０１９６】次いで、ＣＰＵ７１はステップ１８４５に進み、今回の吸気行程に対する正規の燃料噴射量（正規燃料噴射量）fi(k)を、前記ステップ１８１０にて求めた補正前燃料噴射量Fib(k)をステップ１８４０にて求めた燃料フィードバック補正量Ffb(k)で補正して（補正前燃料噴射量Fib(k)に燃料フィードバック補正量Ffb(k)を加えて）求め、続くステップ１８５０にて前記特定気筒のインジェクタに対して正規燃料噴射量fi(k)の燃料の噴射を指示する。これにより、正規燃料噴射量fi(k)に応じた量の燃料が前記特定気筒のインジェクタ３９から噴射される。その後、ＣＰＵ７１はステップ１８５５に進み、次回の本ルーチンの演算のために吸入燃料量誤差Fcerrを積分して誤差積分値SumFcerrを更新し、ステップ１８９５にて本ルーチンを一旦終了する。

【０１９７】以上、説明したように、第１燃料噴射量制御装置によれば、前回の吸気行程に対する実必要燃料量と実吸入燃料量とが求められ、これらの差に基いて同前回の吸気行程に対する燃料量の過不足が算出され、同過不足分が今回以降の燃料噴射量に反映されて補償されて行く。この結果、運転状態量予測手段による予測運転状態量（予測スロットル弁開度、従って、予測吸入空気量）が実際のスロットル弁開度（従って、実際の吸入空気量）と異なることに基く供給燃料量の過不足が直ちに補償されるので、空燃比が略一定に維持され得る。

【０１９８】次に、本発明の第２実施形態に係る燃料噴射量制御装置の実施形態（第２燃料噴射量制御装置）について説明する。この第２燃料噴射量制御装置は、第１燃料噴射量制御装置に対して、ＣＰＵ７１によって達成される機能のみが異なる。従って、以下においては、機能上の相違点のみについて説明する。

【０１９９】図１９に機能ブロック図を示した第２燃料噴射量制御装置は、第１燃料噴射量制御装置が備える、運転状態量取得手段Ａ２、第１吸入空気モデルＡ３、燃料挙動順モデルＡ54、電子制御スロットル弁モデルＭ１、第２吸入空気モデルＡ４、目標空燃比設定手段Ａ５、予測必要燃料量算出手段Ａ51、及び補正前燃料噴射量算出手段（燃料挙動逆モデル）Ａ52を備えるとともに、同第１燃料噴射量制御装置の燃料フィードバック補正量算出手段Ａ55に代わる燃料フィードバック補正量算出手段Ａ61、及び燃料噴射量算出手段Ａ62を備えている。第１燃料噴射量制御装置が備えるモデル、及び手段と同一のモデル、及び手段は、同一の機能を達成するので、詳細な説明を省略する。なお、図１９においては図示が省略されているが、第２燃料噴射量制御装置が適用される内燃機関のスロットル弁開度は、第１燃料噴射量制御装置が備える電子制御スロットル弁ロジックＡ１により、アクセル操作量Accpに対して遅延時間TDだけ遅延された目標スロットル弁開度TAtに基いて制御されている。

【０２００】電子制御スロットル弁モデルＭ１は、第１燃料噴射量制御装置の電子制御スロットル弁モデルＭ１と同一のモデルであって、現時点より先の時点における前記内燃機関の運転状態量であるスロットル弁開度を予測する（予測スロットル弁開度TAestを求める）運転状態量予測手段を構成している。また、運転状態量取得手段Ａ２は、現時点より前の時点における前記内燃機関の実際の運転状態量であるスロットル弁開度TAを取得するようになっている。

【０２０１】第２吸入空気モデルＡ４は、第１燃料噴射量制御装置の第２吸入空気モデルＡ４と同一のモデルであって、特定の気筒の今回の吸気行程に対する吸気弁閉

弁時より前の第１所定時点にて同気筒の今回の吸気行程での吸気弁閉弁時の吸入空気量である予測吸入空気量KLfwdを前記運転状態量予測手段により予測された同第１所定時点より先の時点における運転状態量であるスロットル弁開度TAestと前記内燃機関の吸気系における空気の挙動をモデル化した空気モデルとに基づいて算出する予測吸入空気量算出手段を構成している。

【０２０２】補正前燃料噴射量算出手段Ａ52は、第１燃料噴射量制御装置の補正前燃料噴射量制御手段Ａ52と同一であって、前記第１所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第２所定時点にて前記予測吸入空気量KLfwdに基づいて前記気筒の今回の吸気行程で同気筒に必要とされる燃料量である予測必要燃料量Fcfwdを算出するとともに、前記内燃機関の吸気系への燃料付着挙動を表す燃料挙動モデルの逆モデルの燃料付着率Rp,Rv、及び燃料残留率Pp,Pvを前記吸気弁閉時の予測吸入空気量KLfwd、実際のエンジン回転速度、及び実際の吸気弁開閉タイミングVTにに基いて決定し、この決定された付着率Rp,Rv、及び残留率Pp,Pvの燃料挙動モデルの逆モデルを使用して、同気筒の今回の吸気行程に対し噴射すべき仮の噴射量である補正前燃料噴射量Fib(k)を算出する手段である。

【０２０３】より具体的には、補正前燃料噴射量算出手段Ａ52は、補正前燃料噴射量Fib(k)の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量と同気筒の前回の吸気行程後であって今回の吸気行程前における予測された燃料付着量である予測燃料付着量fwi(k)の燃料のうち同気筒の今回の吸気行程において同気筒に吸入される燃料量との和が、前記算出された予測必要燃料量Fcfwdと等しくなるように（即ち、上記数４に従って）同補正前燃料噴射量Fib(k)を算出するようになっている。

【０２０４】また、補正前燃料噴射量算出手段Ａ52は、前記第２所定時点より前の第３所定時点にて、前記気筒の前回の吸気行程に対する補正前燃料噴射量を算出する基礎となった予測吸入空気量KLfwdに基いて前記燃料挙動モデルに用いる付着率Rp,Rv、及び残留率Pp,Pvを決定するとともに、同付着率Rp,Rv、及び残留率Pp,Pvの燃料挙動モデルと、同気筒の前々回の吸気行程後であって前回の吸気行程前における予測燃料付着量と、同気筒の前回の吸気行程に対する補正前燃料噴射量とに基づいて、同気筒の前回の吸気行程後であって今回の吸気行程前における前記予測燃料付着量fwi(k)を算出する予測燃料付着量算出手段を包含している。

【０２０５】一方、第１吸入空気モデルＡ３は、第１燃料噴射量制御装置の第１吸入空気モデルＡ３と同一であって、前記気筒の前回の吸気行程に対する吸気弁閉弁時より後の時点であって同気筒の今回の吸気行程に対する吸気弁閉弁時より前の第４所定時点にて、同気筒の前回の吸気行程に対する吸気弁閉弁時の実際の吸入空気量である実吸入空気量KLactを前記運転状態取得手段Ａ２により取得された実際の運転状態量である実スロットル弁開度TAactと前記空気モデルとに基づいて算出する実吸入空気量算出手段を構成している。

【０２０６】燃料挙動順モデルＡ54は、第１燃料噴射量制御装置の燃料挙動順モデルＡ54と同様のモデルであり、前記第４所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第５所定時点にて、前記燃料挙動モデルの係数（付着率、残留率）を同気筒の前回の吸気行程に対する吸気弁閉弁時の実吸入空気量KLactに基いて決定するとともに、同付着率及び残留率の燃料挙動モデルと、同気筒の前回の吸気行程に対し実際に噴射された燃料噴射量fi(k-1)と、同気筒の前々回の吸気行程後であって前回の吸気行程前における実際の燃料付着量である実燃料付着量fw(k-1)とに基づいて、同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量fw(k)を算出する実燃料付着量算出手段を構成している。

【０２０７】燃料フィードバック補正量算出手段Ａ61は、前記第３所定時点、及び前記第５所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第６所定時点にて、前記予測燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量fwi(k)と、前記実燃料付着量算出手段により算出された同気筒の前回の吸気行程後であって今回の吸気行程前における実燃料付着量fw(k)との差である燃料付着量誤差Fwerr(k)に基づいて燃料フィードバック補正量Ffb(k)を算出する。

【０２０８】より具体的に述べると、燃料フィードバック補正量算出手段Ａ61は、補正前燃料噴射量算出手段Ａ52が算出した特定気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量fwi(k)（この場合、予測ポート燃料付着量fwpi(k)と予測バルブ燃料付着量fwvi(k)との和である。）と、燃料挙動順モデルＡ54が算出した同特定気筒の前回の吸気行程後であって今回の吸気行程前における実際の燃料付着量fw(k)（この場合、実ポート燃料付着量fwp(k)と実バルブ燃料付着量fwv(k)との和である。）との差を、燃料付着量誤差Fwerr(k)として求める。

【０２０９】即ち、予測燃料付着量fwi(k)は、前回の吸気行程に対する吸気弁閉弁時の予測スロットル弁開度TAest（従って、予測吸入空気量KLfwd）に基いて求められた補正前燃料噴射量Fibと、同予測吸入空気量KLfwdに基いて求められた燃料残留率Ppi,Pvi、及び燃料付着率Rpi,Rviとによって算出された値であるから、前回の吸気行程に対する吸気弁閉弁時の吸入空気量の予測誤差を含んだ値であり、実燃料付着量fw(k)は、実際の正規燃料噴射量fi(k)と、同吸気弁閉弁時の実際のスロットル弁開度TAactに応じて求められた実吸入空気量KLactに基く

燃料残留率Pp,Pv、及び燃料付着率Rp,Rvとによって算出された値であるから、吸入空気量の予測誤差を含まない値である。従って、これらの差である燃料付着量誤差Fwerr(k)は、実際の吸入空気量に対する予測吸入空気量の推定誤差を反映した値となる。

【０２１０】燃料フィードバック補正量算出手段Ａ61は、この付着量誤差fwerr(k)に基いて燃料フィードバック補正量Ffb(k)を求める。この場合、燃料フィードバック補正量算出手段は、上記燃料フィードバック補正量算出手段Ａ55と同様なＰＩコントローラ（比例・積分制御器）であり、燃料フィードバック補正量Ffb(k)を、上記数１０～上記数１２において吸入燃料量誤差Fcerrを燃料付着量誤差Fwerrに、吸入燃料量誤差積分値SumFcerrを燃料付着量誤差積分値SumFwerrにそれぞれ置換した計算式にしたがって求める。

【０２１１】正規燃料噴射量算出手段Ａ62は、前記第２所定時点、及び前記第６所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第７所定時点にて、前記算出された同気筒の今回の吸気行程に対し噴射すべき補正前燃料噴射量Fib(k)に前記算出された燃料フィードバック補正量Ffb(k)を加えることで同補正前燃料噴射量Fib(k)を補正し、これにより前記気筒の今回の吸気行程に対し噴射する正規燃料噴射量fi(k)を算出する。

【０２１２】図１９には図示されていない燃料噴射指示手段は、前記第７所定時点より後の時点であって前記気筒の今回の吸気行程に対する吸気弁閉弁時より前の第８所定時点にて前記燃料噴射手段であるインジェクタ３９に対し前記算出された正規燃料噴射量fi(k)の燃料を噴射するように指示を与える。この結果、前記気筒の今回の吸気行程に対して正規燃料噴射量fi(k)の燃料が噴射される。

【０２１３】このように、第２燃料噴射量制御装置は、吸入空気量の予測誤差が予測燃料付着量の推定誤差として現われるとの知見に基いて、実際の燃料付着量と予測燃料付着量との差に基づき補正前燃料噴射量を補正する。従って、空燃比が一定に維持される。

【０２１４】次に、第２燃料噴射量制御装置の変形例について説明する。この変形例は図２０に示したように、上記第２燃料噴射量制御装置の燃料フィードバック補正量算出手段Ａ61に代わる燃料挙動モデル補正量算出手段Ａ71を備え、同燃料挙動モデル補正量算出手段Ａ71により燃料挙動逆モデルＡ52の燃料付着率Rvi,Rpiと燃料残留率Pvi、Ppiとを補正するようになっている点、及び、燃料挙動逆モデルＡ52の算出する噴射量が直ちに正規燃料噴射量fi(k)となる点においてのみ、同第２燃料噴射量制御装置と異なっている。

【０２１５】即ち、図２０に示した変形例にあっては、燃料挙動モデル補正量算出手段Ａ71は、燃料挙動逆モデルＡ52が算出した特定気筒の前回の吸気行程後であって今回の吸気行程前における予測燃料付着量fwi(k)（この場合、予測ポート燃料付着量fwpi(k)と予測バルブ燃料付着量fwvi(k)との和である。）と、燃料挙動順モデルＡ54が算出した同特定気筒の前回の吸気行程後であって今回の吸気行程前における実際の燃料付着量fw(k)（この場合、実ポート燃料付着量fwp(k)と実バルブ燃料付着量fwv(k)との和である。）との差である燃料付着量誤差Fwerr(k)に基いて、同燃料挙動逆モデルＡ52の燃料付着率Rvi,Rpiと燃料残留率Pvi、Ppiとを補正する。

【０２１６】より具体的には、燃料挙動モデル補正量算出手段Ａ71は、燃料付着量誤差Fwerr(k)が正の値であれば、燃料付着率Rvi,Rpi、及び燃料残留率Pvi、Ppiをそれぞれ減じるための補正量ΔＲ,ΔＰを、同燃料付着量誤差Fwerr(k)の大きさに応じて求め、これにより燃料挙動逆モデルＡ52が使用する燃料付着率Rvi,Rpi、及び燃料残留率Pvi、PpiをそれぞれΔＲ,ΔＰだけ減少補正する。同様に、燃料付着量誤差Fwerr(k)が負の値であれば、燃料付着率Rvi,Rpi、及び燃料残留率Pvi、Ppiをそれぞれ増大するための補正量ΔＲ,ΔＰを、同燃料付着量誤差Fwerr(k)の絶対値の大きさに応じて求め、これにより燃料挙動逆モデルＡ52が使用する燃料付着率Rvi,Rpi、及び燃料残留率Pvi、PpiをそれぞれΔＲ,ΔＰだけ増大補正する。この結果、予測燃料付着量fwiが順次補正されるので、正規燃料噴射量fi(k)が補正されて、空燃比が一定に維持される。

【０２１７】以上説明したように、本発明による内燃機関の燃料噴射量制御装置の各実施形態によれば、運転状態量の予測誤差に起因する燃料の過不足分が実際の運転状態量に基づいて精度良く、且つ直ちに補償されて行くので、空燃比を精度良く目標空燃比に維持することができる。

【０２１８】なお、本発明は上記実施形態に限定されることはなく、本発明の範囲内において種々の変形例を採用することができる。例えば、図２１に示したように、第１燃料噴射量制御装置と第２燃料噴射量制御装置の変形例とを組合せた態様で、燃料噴射量制御装置を構成することもできる。また、上記各実施形態において、内燃機関が定常運転状態にあるとき、今回の吸気行程における吸入空気量がエアフローメータ６１の出力に実質的に基いて決定されるように構成されることが好適である。

【図面の簡単な説明】

【図１】 本発明による燃料噴射量制御装置（第１燃料噴射量制御装置）を火花点火式多気筒内燃機関に適用したシステムの概略構成図である。

【図２】 図１に示したエアフローメータの概略斜視図である。

【図３】 図２に示したエアフローメータの熱線計量部の拡大斜視図である。

【図４】 図１に示したＣＰＵが参照するエアフローメータの出力と吸入空気量（吸入空気流量）との関係を規

定したテーブルを表した図である。

【図５】　スロットル弁開度を制御するとともに燃料噴射量を決定するための各種ロジック、及び各種モデルの機能ブロック図でである。

【図６】　図５に示した噴射量決定手段の詳細を示した機能ブロック図である。

【図７】　図１に示したＣＰＵが参照するアクセルペダル操作量と暫定目標スロットル弁開度との関係を規定したテーブルを示した図である。

【図８】　暫定目標スロットル弁開度、目標スロットル弁開度、及び予測スロットル弁開度の変化を示したタイムチャートである。

【図９】　予測スロットル弁開度を算出する際に用いる関数を示したグラフである。

【図１０】　図６に示した噴射量決定手段が備える各機能ブロックによる計算タイミングを示した図である。

【図１１】　図１に示したＣＰＵが実行する目標スロットル弁開度、及び予測スロットル弁開度を演算するためのプログラムを示したフローチャートである。

【図１２】　図１に示したＣＰＵが実行する予測吸入空気量を算出するためのプログラムを示したフローチャートである。

【図１３】　図１に示したＣＰＵが実行する予測スロットル通過空気流量を算出するためのプログラムを示したフローチャートである。

【図１４】　図１に示したＣＰＵが実行する予測筒内吸入空気流量を算出するためのプログラムを示したフローチャートである。

【図１５】　図１に示したＣＰＵが実行する実吸入空気量を算出するためのプログラムを示したフローチャートである。

【図１６】　図１に示したＣＰＵが実行する実スロットル通過空気流量を算出するためのプログラムを示したフローチャートである。

【図１７】　図１に示したＣＰＵが実行する実筒内吸入空気流量を算出するためのプログラムを示したフローチャートである。

【図１８】　図１に示したＣＰＵが実行する燃料噴射実行（正規燃料噴射量計算）のためのプログラムを示したフローチャートである。

【図１９】　本発明による他の燃料噴射量制御装置（第２燃料噴射量制御装置）を示した機能ブロック図である。

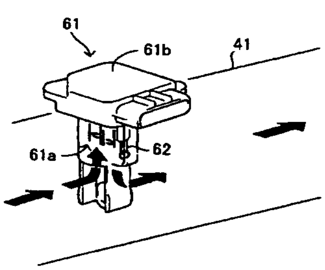
【図２０】　図１９に示した第２燃料噴射量制御装置の変形例を示した機能ブロック図である。

【図２１】　第１燃料噴射量制御装置と第２燃料噴射量制御装置の変形例を組合せた本発明による他の燃料噴射量制御装置を示した機能ブロック図である。

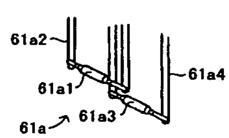
【符号の説明】

１０…火花点火式多気筒内燃機関、２０…シリンダブロック部（エンジン本体部）、２５…燃焼室、３１…吸気ポート、３２…吸気弁、３９…インジェクタ、４１…吸気管、４３…スロットル弁、４３ａ…スロットル弁アクチュエータ、７０…電気制御装置、７１…ＣＰＵ。

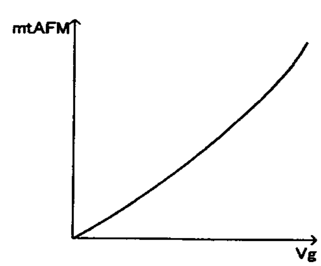
【図２】



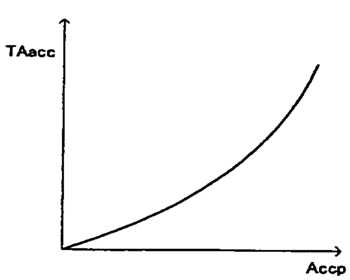
【図３】



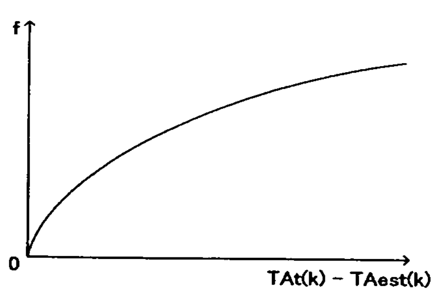
【図４】



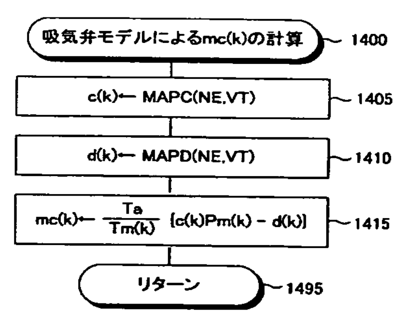
【図７】



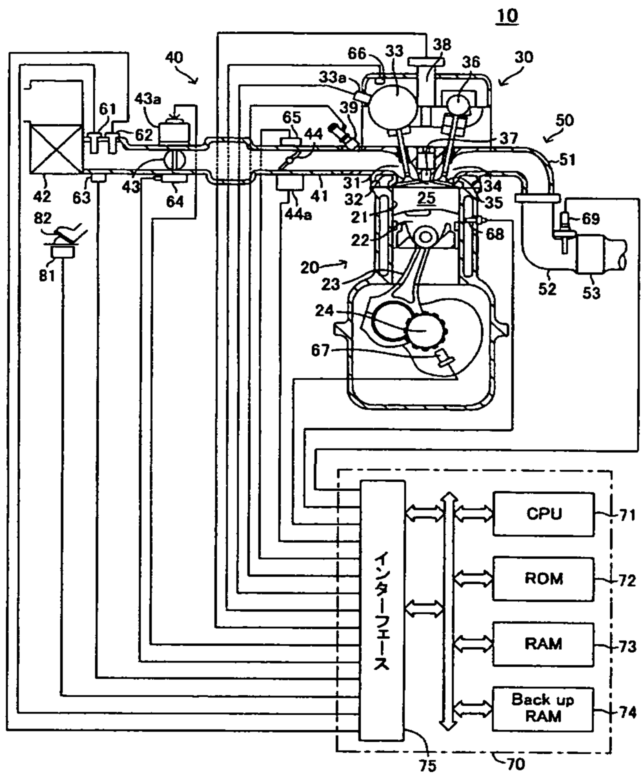
【図９】



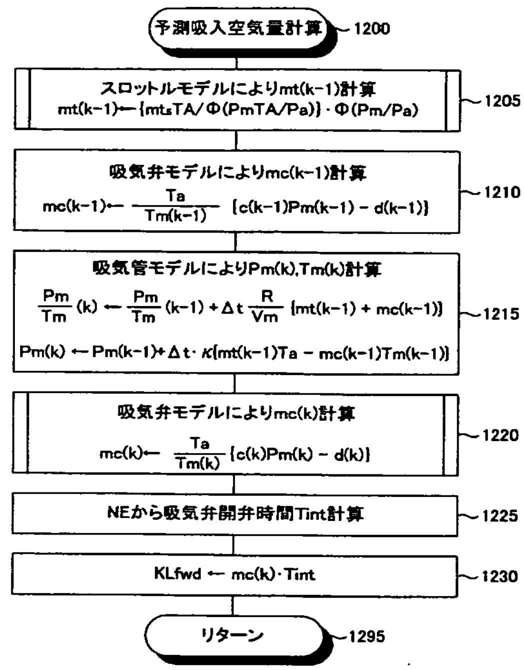
【図１４】



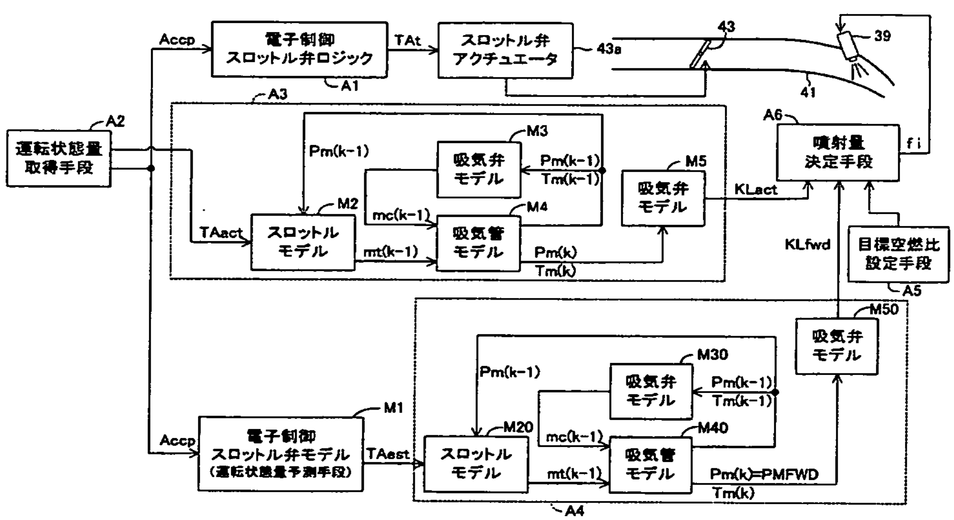
【図１】


10
40
30
50
66
33
38
36
33a
39
61
43a
62
65
44
37
51
31
34
25
32
35
42
63
43
41
64
44a
21
22
68
69
82
20
23
52
53
81
24
67
CPU
ROM
RAM
Back up
RAM
インターフェース
71
72
73
74
75
70

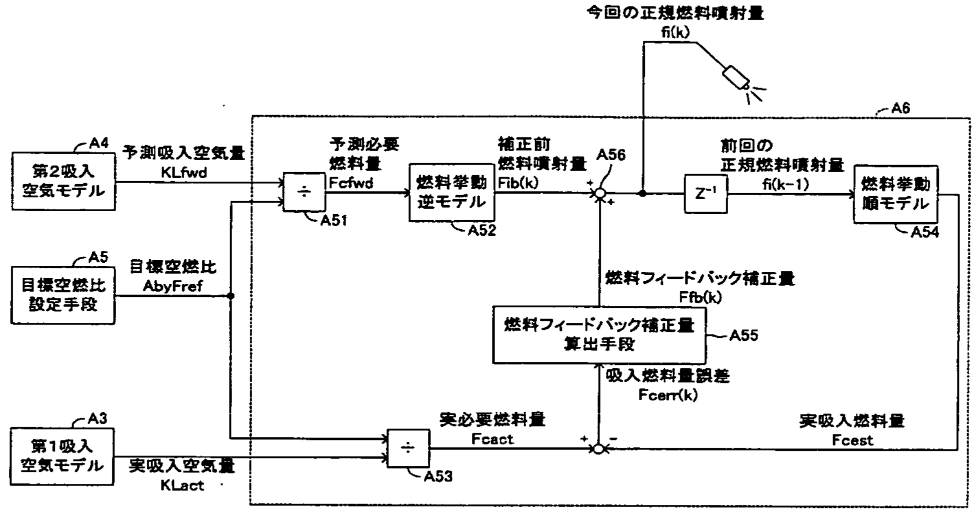
【図１２】


予測吸入空気量計算
1200
スロットルモデルによりmt(k-1)計算
mt(k-1)←{mtsTA/Φ(PmTA/Pa)}・Φ(Pm/Pa)
1205
吸気弁モデルによりmc(k-1)計算
mc(k-1)← Ta/Tm(k-1) {c(k-1)Pm(k-1) - d(k-1)}
1210
吸気管モデルによりPm(k),Tm(k)計算
Pm/Tm (k) ← Pm/Tm (k-1) + Δt R/Vm {mt(k-1) + mc(k-1)}
Pm(k) ← Pm(k-1)+Δt・κ{mt(k-1)Ta - mc(k-1)Tm(k-1)}
1215
吸気弁モデルによりmc(k)計算
mc(k)← Ta/Tm(k) {c(k)Pm(k) - d(k)}
1220
NEから吸気弁開弁時間Tint計算
1225
KLfwd ← mc(k)・Tint
1230
リターン
1295

【図５】

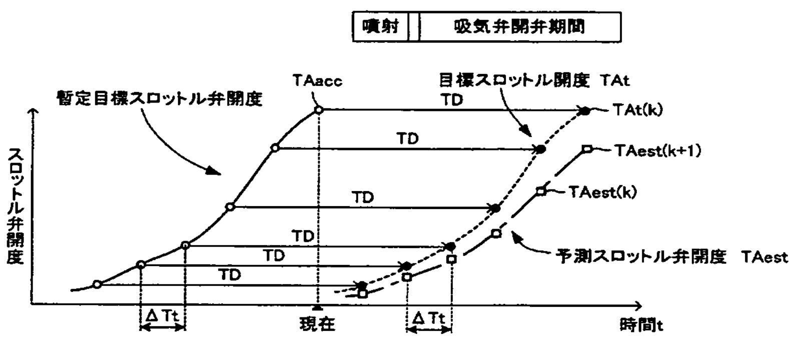

Accp
電子制御
スロットル弁ロジック
TAt
スロットル弁
アクチュエータ
43a
43
39
41
A1
A3
A2
運転状態量
取得手段
Pm(k-1)
M3
吸気弁
モデル
Pm(k-1)
Tm(k-1)
M5
吸気弁
モデル
A6
噴射量
決定手段
fi
KLact
M2
mc(k-1)
M4
TAact
スロットル
モデル
mt(k-1)
吸気管
モデル
Pm(k)
Tm(k)
KLfwd
目標空燃比
設定手段
A5
M50
吸気弁
モデル
M30
Pm(k-1)
吸気弁
モデル
Pm(k-1)
Tm(k-1)
M1
M20
mc(k-1)
M40
Accp
電子制御
スロットル弁モデル
(運転状態量予測手段)
TAest
スロットル
モデル
mt(k-1)
吸気管
モデル
Pm(k)=PMFWD
Tm(k)
A4

【図６】



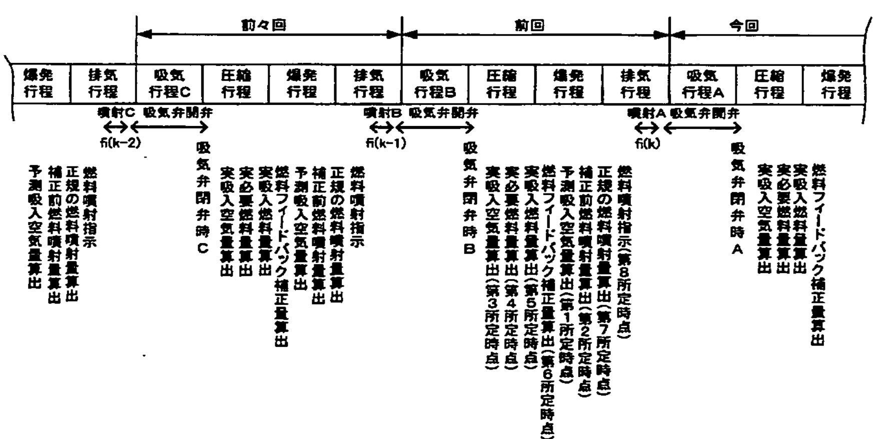
今回の正規燃料噴射量
fi(k)
A6
A4
第2吸入空気モデル
予測吸入空気量
KLfwd
予測必要燃料量
Fcfwd
A51
燃料挙動逆モデル
A52
補正前燃料噴射量
Fib(k)
A56
Z⁻¹
前回の正規燃料噴射量
fi(k−1)
燃料挙動順モデル
A54
A5
目標空燃比設定手段
目標空燃比
AbyFref
燃料フィードバック補正量
Ffb(k)
燃料フィードバック補正量算出手段
A55
吸入燃料量誤差
Fcerr(k)
A3
第1吸入空気モデル
実吸入空気量
KLact
A53
実必要燃料量
Fcact
実吸入燃料量
Fcest

【図８】



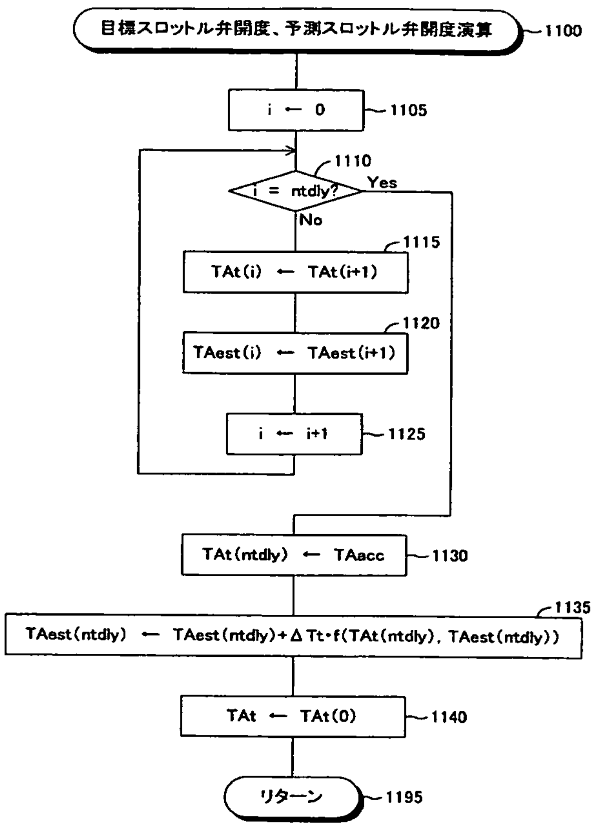
噴射
吸気弁開弁期間
TAacc
暫定目標スロットル弁開度
目標スロットル開度 TAt
TD
TAt(k)
TAest(k+1)
TAest(k)
予測スロットル弁開度 TAest
スロットル弁開度
ΔTt
現在
ΔTt
時間t

【図１０】

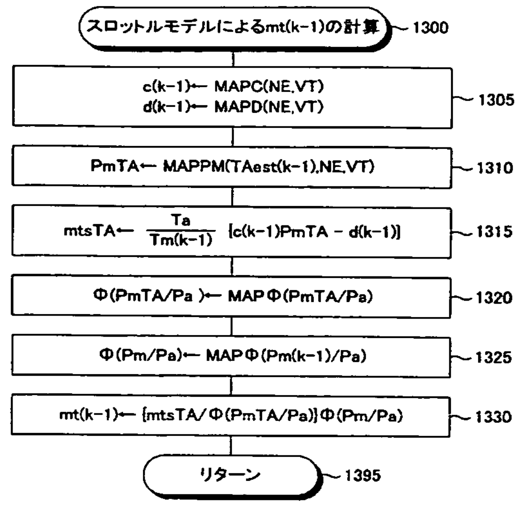


前々回
前回
今回
爆発行程
排気行程
吸気行程C
圧縮行程
爆発行程
排気行程
吸気行程B
圧縮行程
爆発行程
排気行程
吸気行程A
圧縮行程
爆発行程
噴射C
吸気弁開弁
fi(k−2)
噴射B
吸気弁開弁
fi(k−1)
噴射A
吸気弁開弁
fi(k)
予測吸入空気量算出
補正前の燃料噴射量算出
正規の燃料噴射量算出
燃料噴射指示
吸気弁閉弁時C
実吸入空気量算出
実必要燃料量算出
実吸入燃料量算出
燃料フィードバック補正量算出
予測吸入空気量算出
補正前燃料噴射量算出
正規の燃料噴射量算出
燃料噴射指示
吸気弁閉弁時B
実吸入空気量算出(第3所定時点)
実必要燃料量算出(第4所定時点)
実吸入燃料量算出(第5所定時点)
燃料フィードバック補正量算出(第6所定時点)
予測吸入空気量算出(第1所定時点)
補正前燃料噴射量算出(第2所定時点)
正規の燃料噴射量算出(第7所定時点)
燃料噴射指示(第8所定時点)
吸気弁閉弁時A
実吸入空気量算出
実必要燃料量算出
実吸入燃料量算出
燃料フィードバック補正量算出

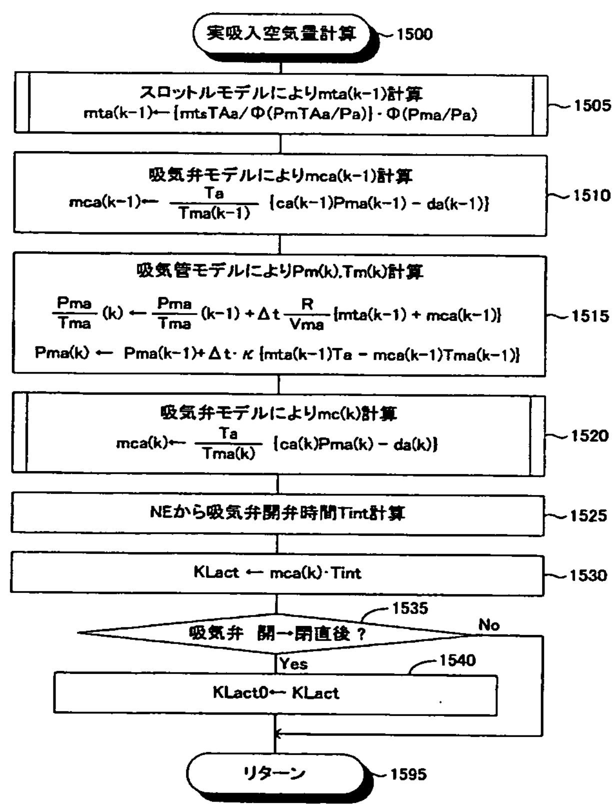
【図１１】



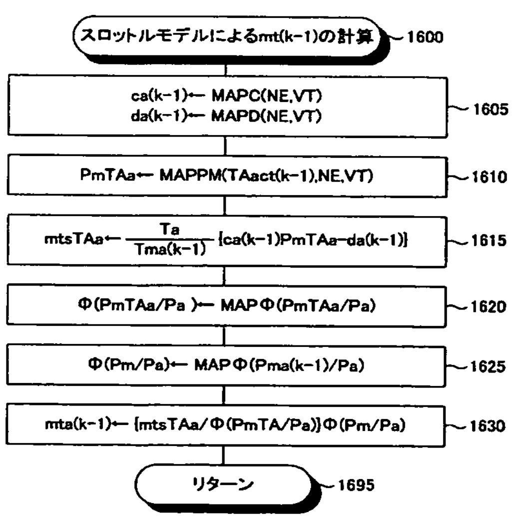
【図１３】



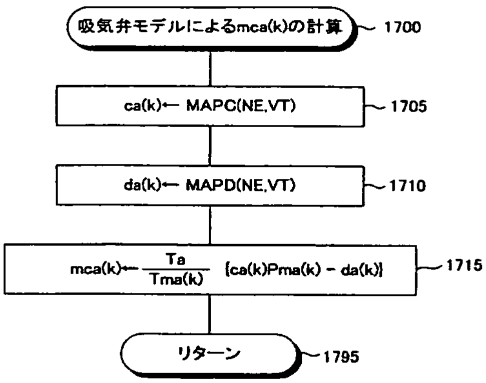
【図１５】



【図１６】

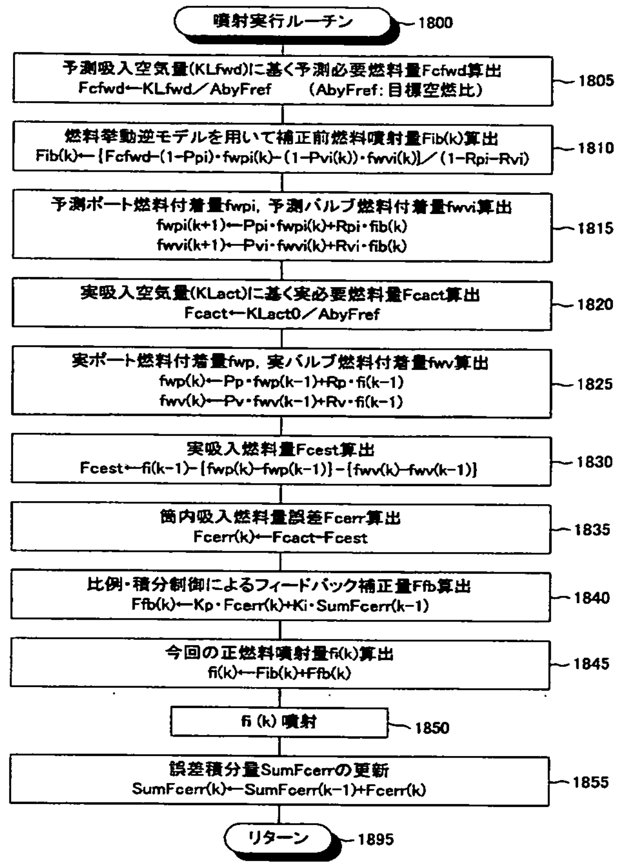


【図１７】



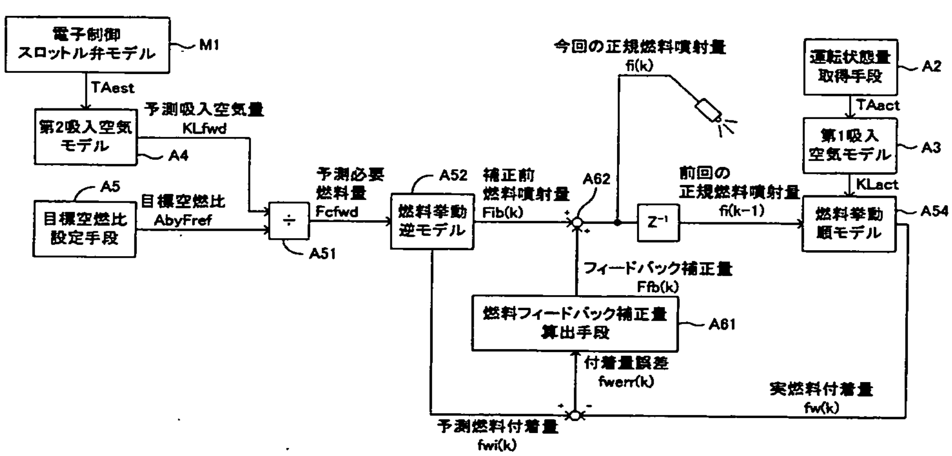
吸気弁モデルによるmca(k)の計算
1700
ca(k)← MAPC(NE,VT)
1705
da(k)← MAPD(NE,VT)
1710
mca(k)← $\frac{Ta}{Tma(k)}$ {ca(k)Pma(k) − da(k)}
1715
リターン
1795

【図１８】



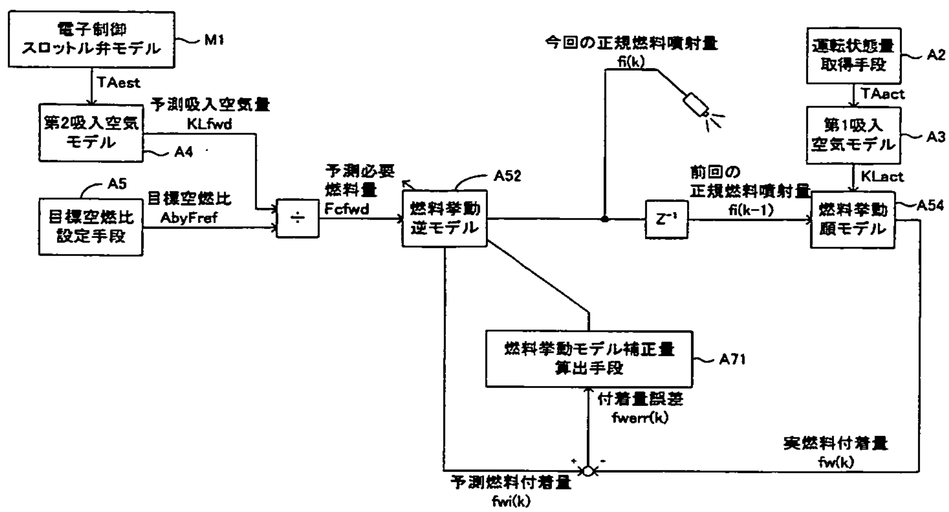
噴射実行ルーチン
1800
予測吸入空気量(KLfwd)に基く予測必要燃料量Fcfwd算出
Fcfwd←KLfwd／AbyFref　(AbyFref: 目標空燃比)
1805
燃料挙動逆モデルを用いて補正前燃料噴射量Fib(k)算出
Fib(k)←{Fcfwd−(1−Ppi)・fwpi(k)−(1−Pvi(k))・fwvi(k)}／(1−Rpi−Rvi)
1810
予測ポート燃料付着量fwpi, 予測バルブ燃料付着量fwvi算出
fwpi(k+1)←Ppi・fwpi(k)+Rpi・fib(k)
fwvi(k+1)←Pvi・fwvi(k)+Rvi・fib(k)
1815
実吸入空気量(KLact)に基く実必要燃料量Fcact算出
Fcact←KLact0／AbyFref
1820
実ポート燃料付着量fwp, 実バルブ燃料付着量fwv算出
fwp(k)←Pp・fwp(k−1)+Rp・fi(k−1)
fwv(k)←Pv・fwv(k−1)+Rv・fi(k−1)
1825
実吸入燃料量Fcest算出
Fcest←fi(k−1)−{fwp(k)−fwp(k−1)}−{fwv(k)−fwv(k−1)}
1830
筒内吸入燃料量誤差Fcerr算出
Fcerr(k)←Fcact−Fcest
1835
比例・積分制御によるフィードバック補正量Ffb算出
Ffb(k)←Kp・Fcerr(k)+Ki・SumFcerr(k−1)
1840
今回の正燃料噴射量fi(k)算出
fi(k)←Fib(k)+Ffb(k)
1845
fi (k) 噴射
1850
誤差積分量SumFcerrの更新
SumFcerr(k)←SumFcerr(k−1)+Fcerr(k)
1855
リターン
1895

【図１９】

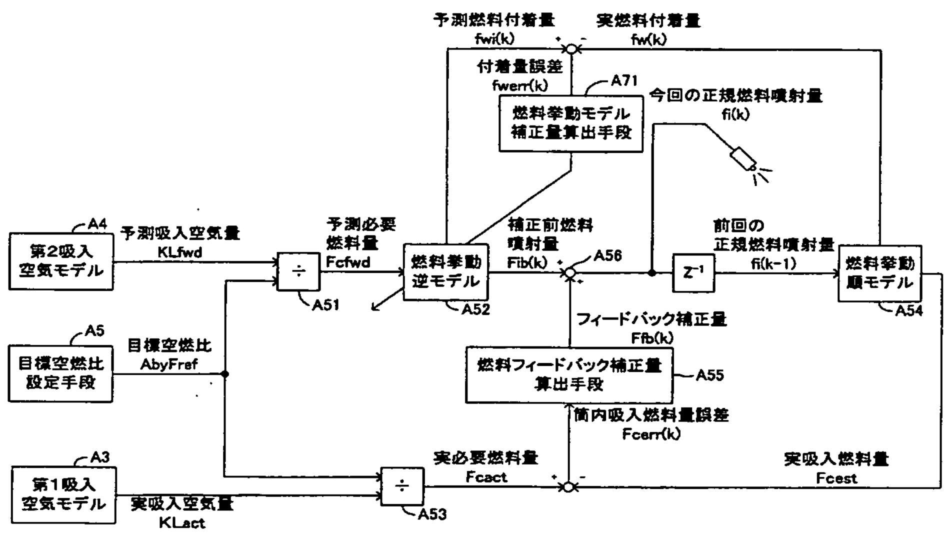


電子制御スロットル弁モデル
M1
TAest
第2吸入空気モデル
A4
予測吸入空気量
KLfwd
A5
目標空燃比設定手段
目標空燃比
AbyFref
÷
A51
予測必要燃料量
Fcfwd
A52
燃料挙動逆モデル
補正前燃料噴射量
Fib(k)
A62
今回の正規燃料噴射量
fi(k)
z^{-1}
前回の正規燃料噴射量
fi(k−1)
運転状態量取得手段
A2
TAact
第1吸入空気モデル
A3
KLact
燃料挙動順モデル
A54
フィードバック補正量
Ffb(k)
燃料フィードバック補正量算出手段
A61
付着量誤差
fwerr(k)
実燃料付着量
fw(k)
予測燃料付着量
fwi(k)

【図２０】


電子制御
スロットル弁モデル
M1
TAest
第2吸入空気
モデル
A4
予測吸入空気量
KLfwd
A5
目標空燃比
設定手段
目標空燃比
AbyFref
÷
予測必要
燃料量
Fcfwd
燃料挙動
逆モデル
A52
今回の正規燃料噴射量
fi(k)
Z⁻¹
前回の
正規燃料噴射量
fi(k-1)
運転状態量
取得手段
A2
TAact
第1吸入
空気モデル
A3
KLact
燃料挙動
順モデル
A54
燃料挙動モデル補正量
算出手段
A71
付着量誤差
fwerr(k)
実燃料付着量
fw(k)
予測燃料付着量
fwi(k)

【図２１】


予測燃料付着量
fwi(k)
実燃料付着量
fw(k)
付着量誤差
fwerr(k)
A71
燃料挙動モデル
補正量算出手段
今回の正規燃料噴射量
fi(k)
A4
第2吸入
空気モデル
予測吸入空気量
KLfwd
予測必要
燃料量
Fcfwd
÷
A51
燃料挙動
逆モデル
A52
補正前燃料
噴射量
Fib(k)
A56
Z⁻¹
前回の
正規燃料噴射量
fi(k-1)
燃料挙動
順モデル
A54
フィードバック補正量
Ffb(k)
燃料フィードバック補正量
算出手段
A55
A5
目標空燃比
設定手段
目標空燃比
AbyFref
筒内吸入燃料量誤差
Fcerr(k)
A3
第1吸入
空気モデル
実吸入空気量
KLact
÷
A53
実必要燃料量
Fcact
実吸入燃料量
Fcest

フロントページの続き

Ｆターム(参考)　3G084 AA03 BA05 BA09 BA13 CA04
CA06 DA04 DA07 DA12 EA07
EB08 EB12 EC02 EC04 FA01
FA08 FA10 FA11 FA13 FA20
FA29 FA33
3G301 HA01 JA00 JA11 JA12 JA14
KA12 KA16 LA03 LB01 LC02
LC04 MA01 MA12 MA13 MA14
NA08 NA09 NC04 ND02 NE02
NE07 PA01A PA04Z PA06Z
PA07Z PA09Z PA11A PA11Z
PB03A PD02A PD02Z PE01Z
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